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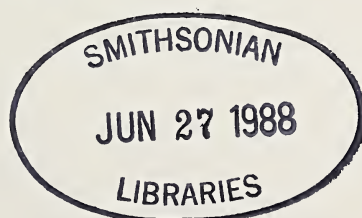
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**The Redbreast Sunfish**  
**(*Lepomis auritus*) in a Thermally**  
**Influenced Section of the**  
**James River, Virginia**

**John R. Saecker and William S. Woolcott**  
Biology Department  
University of Richmond

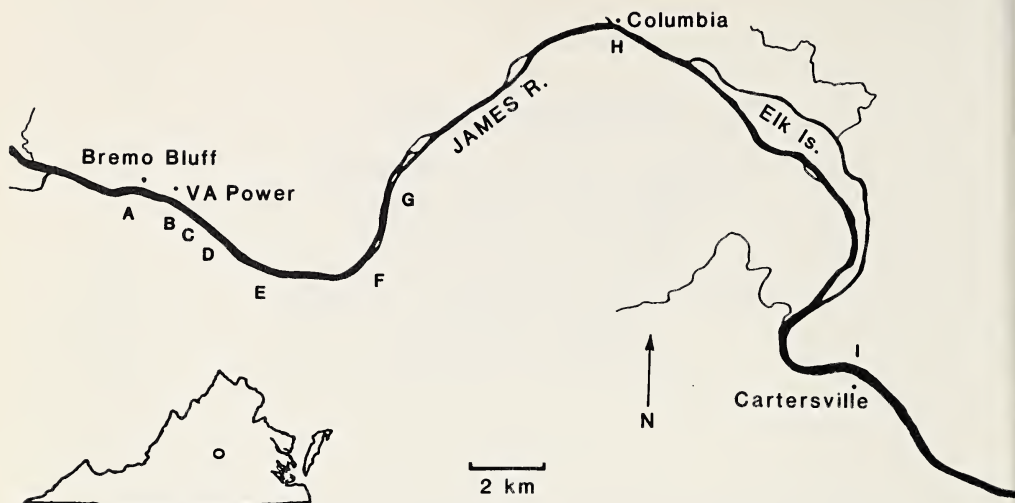
ABSTRACT

The length, and sex of approximately 1000 redbreast sunfish (*Lepomis auritus*) collected from October 1971-September 1973 from a thermally influenced stretch of the James River in the central Virginia Piedmont, were examined in relation to season of capture. Age group II comprised the greatest percentage of the total collection of fishes from the ambient temperature environment whereas age group 0 was the dominant group in the heated habitat. Seasonal influences on abundance were not as pronounced in the heated habitat as in the natural environment. Seasonal composition by age group was influenced by reproduction and feeding activities. Male redbreast sunfish had greater mean annual lengths than females in age groups III and IV from the ambient temperature habitat and in age groups II and III from the heated habitat. Fish in age group 0 and I and males in age group II from the heated environment exhibited greater annual mean lengths than their corresponding age groups in the ambient waters. The overall sex ratio of fish from both habitats did not differ significantly from a 1:1 ratio ( $P=.05$ ).

INTRODUCTION

The redbreast sunfish, *Lepomis auritus*, a widely occurring species in streams of southeastern Atlantic and Gulf of Mexico drainages, is the predominant centrarchid in the James River, Virginia (Raney, 1950). A two-year investigation of a thermally affected section of the James River (Woolcott, 1974) included a regular fish sampling regimen that produced an abundance of redbreast sunfish from artificially heated and ambient temperature habitats. While there have been several studies on various aspects of this popular pan fish's life history, those that are thermally related are limited to studies of prespawning behavior (Breder and Nigrelli, 1935), growth (O'Rear, 1968), high temperature tolerance (Clugston, 1973), and feeding and body condition (Lattimore and Gibbons, 1976).

The objective of this study was to compare seasonal data (age groups, sex ratios and length frequency distributions) of redbreast sunfish populations in the heated effluent from an electric power station with data of populations in adjacent natural ambient temperature habitats. Data from our study take on added significance with the Virginia Commission of Game and Inland Fisheries study of the James River fish populations now underway.



**Figure 1.**  
**The James River, Virginia study area. Capital letters denote collecting transects.**

#### MATERIALS AND METHODS

The study area was a 30 km section of the James River extending through the Piedmont Province from Bremono Bluff to Cartersville, Virginia (Fig. 1). Virginia Power operated a 210 mw fossil (present 235 mw) fueled power station located on the north side of the river at Bremono Bluff, Virginia. The plant utilized from 2 - 13% of the river water for cooling purposes depending on the operational demand and the flow ( $m^3/sec$ ) of the river. Discharged water had a  $\Delta t$  of 4 - 13 C and could be identified as a narrow plume extending approximately 23 m outward from the north shore at the outfall and downstream for approximately 8 km (Kirk, 1974).

The river is about 250 m wide, characterized by an irregular, rocky substrate from side to side. Habitats sampled varied with river discharge. At high water (river discharge over 275  $m^3/sec$ ) shoreline collecting sites were associated with a mud and debris substrate. All areas had mixed rubble, sand and debris substrates and were in moderately flowing water (approximately 45 cm/sec) when intermediate river volumes (120-275  $m^3/sec$ ) were recorded. Low water levels (discharge less than 120  $m^3/sec$ ) resulted in the most diverse conditions revealing riffles, slow moving pools (approximately 15 cm/sec), weedbeds of water willow (*Justica americana*), and boulders at specific areas. Substrates consisted mostly of rubble mixed with sand and debris.

Nine transects, each with a collecting station on the north and south sides of the river, were established. Collecting sites of each transect were paired as close as possible with regard to most environmental factors except those associated with the heated discharge (northside). The control transect (A) was 1.2 km above the power station discharge. Transect B included the point of discharge and the area immediately downstream; the remaining transects C-I were 0.8, 1.6, 4.0, 5.6, 8.0, 16.0 and 30.0 km; respectively, downriver from the discharge tunnel. Both collecting sites of transect A and all southside stations provided natural (ambient) temperature habitats. Only northside stations B-G were considered artificially heated environments as



the thermal plume usually was not identifiable 8.0 km below the point of discharge (Woolcott, 1972). After the first seven months of the study sampling was discontinued at transects E and F, 4.0 and 5.6 km respectively, from the point of discharge, and downstream transects H and I as they were not influenced by the plume.

Fishes were collected by electrofishing (220 volts, 1 - 3 amps, D. C.) from October 1971 - September 1973 on an approximate bimonthly basis. Collections were made wading (October 1971-March 1972 only) in shallow areas with electrodes, and from an electrofishing boat with trailing cathode electrodes and an anode dipnet (5 mm<sup>2</sup> mesh). A second dipnet, without current, aided in netting stunned fish. Distance from shore during collections ranged from 0.6 - 9.0 m, varying with river flow; shocking time was 20 minutes at each station, which allowed approximately 200 m of shoreline to be sampled. Fish were preserved in 10% formalin in the field, transferred to the laboratory and stored in 40% isopropyl alcohol.

Redbreast sunfish specimens were measured (standard length in mm) with a drafting compass and a calibrated metric steel rule. A ventral incision was made in the abdominal cavity and sex was determined either by gross examination or microscopic inspection of the gonads. Scales used in determining age were removed from the left side of fish just posterior to the opercle and below the lateral line following the method of Lagler (1956). When scales from this area were not readable, those from the corresponding area on the right side were used. After removing the epidermis by scrubbing the scale with 5% KOH, the scales either were mounted dry or in glycerol on standard glass microscope slides. A microprojection apparatus (10 X objective) attached to a slide projector provided an enlarged image (340 X and 1000 X) for reading the dry mounted scales; glycerol mounts were viewed under a dissecting microscope (30 X and 80 X). When two of three separate counts of annuli were in agreement the reading was accepted. Where annuli were difficult to interpret, verification of age was made by others with experience in scale reading.

Insufficient data due to periods of flooding and the absence of redbreast sunfish in certain collection periods precluded statistical analysis by individual stations and seasons of two separate years. Therefore, all stations, depending on their relation to the thermal plume (i.e. ambient and heated), were grouped into one natural and one heated environment and the corresponding calendar seasons of two years were combined. With an 8km plume, only northside stations B, C, D, and G were heated, with decreasing thermal influence downstream due to mixing. Within each environment, age groups were analyzed for length by season and sex. Total and seasonal population compositions (% of age groups) were determined and the ratios of male to female were tested by age group and season. Comparison of age groups across environments was made for length by season and sex, and ratios of male to female in sample populations were compared seasonally.

Length data were analyzed using a two-factor analysis of variance test (Steele and Torre, 1960) and an unpaired t-test (Hayslett, 1968). The chi square formula (Bishop, 1966) and a Z-formula (Walpole and Meyers, 1972) were used for analysis of abundance and sex ratio data. In all statistical tests significance was accepted at the 0.95 confidence level. The terms average and mean are used interchangeably throughout this paper.

## RESULTS

Considerable variation in the production and dissipation of heat at steam electrical generating stations is to be expected with variation in electrical output and environmental conditions

Table 1. Seasonal temperature (C) range and mean for natural and heated water habitats in the James River near Bremono Bluff, Virginia (October 1971 - September 1973). Data from Kirk (1974).

	Natural Habitat Range	Temperature (C)		Heated Habitat Range	Mean
		Mean			
Fall	6-23	13		6-35	17
Winter	2-12	6		4-20	10
Spring	10-26	18		10-37	23
Summer	20-28	24		22-39	30

Table 2. Seasonal occurrence (% of total samples/season in which species occurred) and abundance (number of specimens/collection) of redbreast sunfish from natural (N) and heated (H) habitats of the James River near Bremono Bluff, Virginia during extreme high and low seasonal river discharges (October 1971 through September 1973).

Season	River Discharge (m <sup>3</sup> /sec)	Habitat	% Occurrence	Av. Abundance/ Collection
Fall	437	N	10	0.1
		H	25	0.5
	115	N	100	3.6
		H	100	3.8
Winter	428	N	50	0.5
		H	50	0.8
	119	N	60	2.2
		H	100	4.0
Spring	324	N	90	5.1
		H	67	1.3
	95	N	80	2.6
		H	100	1.7
Summer	277	N	50	0.5
		H	0	0.0
	48	N	100	10.8
		H	100	4.4

(Parker and Krenkel, 1969). The Bremono Power Station, a swingload facility, varied its electrical output from a low of approximately 110 mw in the late night and early morning hours as consumer demand was reduced, to a peak output of 210 mw, usually during late afternoon or early evening hours. This pattern of production caused considerable diurnal fluctuation in heat loading to the river from day to day (Kirk, 1974). Also, seasonal variation in consumer electricity demand was reflected in an increased plant production, thus increasing release of heated effluent, during the hot months of summer.



Ambient water temperature on collection dates ranged from a seasonal average of 6 C in winter to 24 C in summer. In the heated habitat seasonal temperature means varied from a low 10 C in winter to a high 30 C in summer (Table 1). The greatest increase in thermal plume temperature was 13 C above ambient water temperature (recorded December 8, 1972 and June 4, 1973). The  $\Delta t$  values downstream from the point of discharge were directly related to the combined effects of power station operation and river flow. Generally  $\Delta t$  values were higher and extended further downriver when periods of peak plant production occurred simultaneously with low river discharge. Twice during this study flooding halted plant operation, resulting in a temporary disappearance of the thermal plume. During those periods only fish from the ambient temperature water (southside stations and station A) were used in data analyses.

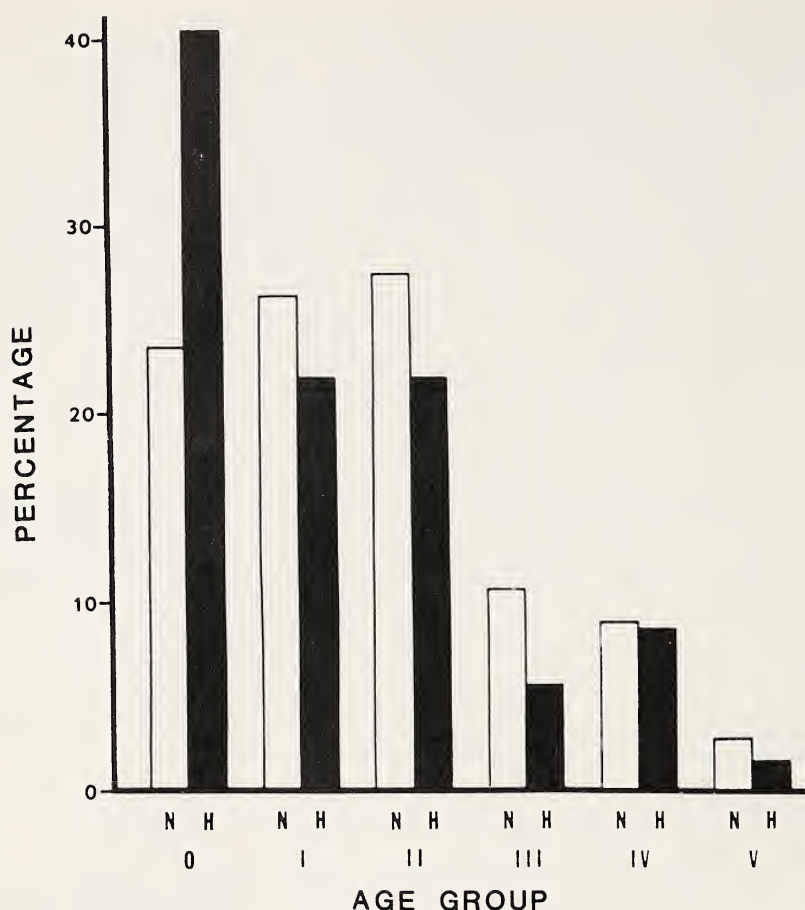
River discharge during the two year period ranged from a monthly mean of 48 m<sup>3</sup>/sec in September 1973 to 496 m<sup>3</sup>/sec in April 1973. Daily mean flow varied from 39 m<sup>3</sup>/sec in September of 1972 to 2005 m<sup>3</sup>/sec in October 1972. In general, discharge volumes were lowest during June, July and August.

A total of 1004 redbreast sunfish were collected, 736 from ambient temperature and 268 from heated stations. Frequency of occurrence was approximately equal in both habitats for each season (Table 2). Size of fish collections could be correlated with seasonal temperature and river discharge. During colder months, fall and winter, abundance per collection was greater in the heated water for both high (275 m<sup>3</sup>/sec) and low (120 m<sup>3</sup>/sec) river discharges. For the warmer months, spring and summer, however, natural temperature habitats registered a greater abundance per collection for the higher and lower river discharges. Within each habitat the trend was toward a greater frequency of occurrence and abundance per collection during low river discharges throughout the year.

Six distinct age groups (0 - V) were identified, which were corroborated by length frequency distributions. All ages were represented in both habitats. Two year old fish comprised the largest number (206; 27.5%) in the natural habitat and first year fish formed the largest group (109; 40.5%) in the heated water. In both environments age groups 0, I and II accounted for relatively high percentages of the total population when compared with those of age groups III, IV and V (Fig. 2).

Percentages of the total seasonal collections represented by each age group show the greatest variation (64%) for the natural habitat was in age group 0 (67.5% in winter to 3.5% in summer) and the smallest variation (6.3%) was in age group V (6.3% in spring to 0% in winter) (Fig. 3 ABCD). Age groups I - IV demonstrated extreme seasonal fluctuations of 29.6%, 27.2%, 19.4% and 8.8%, respectively. Similarly, as in natural habitat, the greatest variation (53.9%) for the heated habitat was recorded for age group 0 (62.0% in winter to 8.1% in spring) and the smallest (3.7%) was observed in age group V (3.7% in summer to 0% in fall). Intermittent age groups, however, did not respond to season as did those of the natural environment. The maximum variation of these age groups were 27.8% (II), 19.9% (IV), 11.5% (III), and 10.3% (I). When the maximum variation of seasonal percentages were compared across habitats, the larger differences appeared in age groups I (difference of 19.3%), IV (difference of 11.1%) and III (difference of 7.9%).

The overall sex ratio for both populations approached a proportion of 1:1 (natural; male 337, female 339; heated; male 124, female 112); however, this was not the case in the separate age groups and seasons. Age group analysis (seasons combined) revealed a significantly higher number of females in one year old fish from ambient water and a predominant number of males in four year old fish from both habitats (Table 3). Chi square tests for seasonal variation from a 1:1 sex ratio in natural



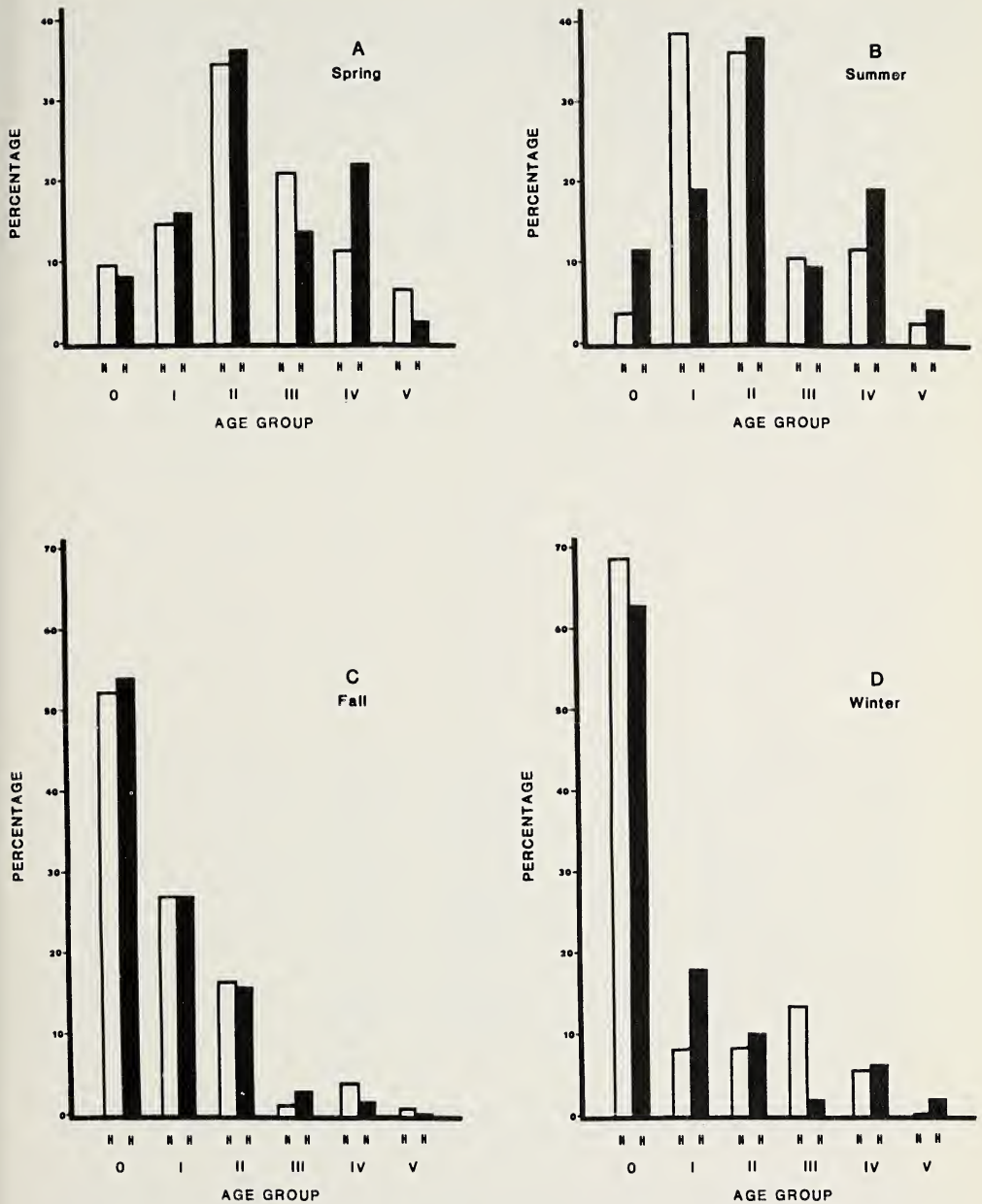
**Figure 2.**

Total (seasons combined) composition of sample populations of redbreast sunfish from natural (N, white bar) and heated (H, black bar) water temperature habitats in the James River near Bremono Bluff, Virginia (October 1971-September 1973). Composition expressed as percentages of the sample populations which each age group comprised.

temperature waters (Table 4) showed values that significantly favored females in age group 0 (only 60% of specimens of this group could be sexed) during fall (31 males, 52 females) and in age group I in the spring (9 males, 20 females). Males significantly dominated age group II in spring (48 males, 28 females) in natural waters and age group IV in summer for both natural (23 males, 5 females) and heated (10 males, 0 females) environments. Age group V fish from ambient temperature water were represented by one female collected in fall, seven males and six females in spring, and three males and one female in the summer. In the heated water one age V male was captured in each of the winter and spring seasons whereas two were collected during the summer.

Seasonal comparison (Z formula) of the proportion of the





**Figure 3.**  
**ABCD.** Seasonal composition of sample populations of redbreast sunfish from natural (N, white bar) and heated (H, black bar) water temperature habitats in the James River near Bremo Bluff, Virginia (October 1971-September 1973).

Table 3. Mean standard lengths of redbreast sunfish by sex (sexes combined in age group O) from natural (N) and heated (H) habitats in the James River near Bremo Bluff, Virginia, October 1971 - September 1973. Tests are  $\chi^2$ , variation from a 1:1 sex ratio/habitat/age group; T, difference in length between sexes/habitat/age group by season; and  $T_t$ , difference in length between corresponding sexes from each habitat/age group by season.

Age Group and Habitat	Sex	No.	Standard Length		$\chi^2$	Tests	
			$\bar{x}$	2 s.e.		T	$T_t$
O							
N	Total	178	33.56	1.22	-	-	
3.43*	H	Total	109	37.31	1.94	-	-
I							
N	M	79	66.16	3.32	5.38*	0.29	
3.78*	F	111	65.49	3.06			
5.41*	H	M	32	78.67	0.62	1.29	
	F	26	84.67	6.66			
II							
N	M	109	97.10	3.56	0.69	0.18	
4.48*	F	97	97.55	3.24			1.65
	H	M	26	114.21	0.83	2.84*	
	F	33	102.96	6.02			
III							
N	M	46	132.77	4.72	2.13	2.13*	0.57
	F	33	126.13	3.24			1.51
	H	M	9	136.00	0.60	3.12*	
	F	6	120.08	5.66			
IV							
N	M	45	151.52	3.08	9.61*	5.07*	0.52
	F	20	137.72	4.26			1.20
	H	M	20	150.20	3.12	12.56*	1.10
	F	3	145.00	13.58			
V							
N	M	10	156.85	3.18	0.22	0.24	0.25
	F	8	155.68	10.00			
	H	M	4	156.00	7.64	-	-
	F	0	-	-			

\* 0.05

number of males to the total number of the seasonal population across environments proved significant ( $P=0.05$ ) only in age group II during the spring, when more females (5 males, 9 females) were collected on the heated habitat, and more males (48 males, 28 females) were captured in the natural habitat.

Results of two factor ANOVA (age group x season) for lengths of redbreast sunfish, age groups O-IV, in both habitats showed main effect age group to be highly significant ( $P=0.001$ ) on an annual basis. Successive age groups (I-IV) in the natural habitat had higher mean lengths values than did the preceding age group. Results were the same for the heated habitat. Age group III in the heated habitat was omitted as no specimens were collected during the winter season.

# THE REDBREAST SUNFISH

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Table 4. Seasonal sexual composition of populations of redbreast sunfish, age groups O-IV, from natural (N) and heated (H) habitats in the James River, near Bremono Bluff, Virginia, October 1971 - September 1973. Values are expressed as seasonal abundance of each sex and Chi square ( $\chi^2$ ) as variance from expected 1:1 sex ratio/habitat.

Age Group Habitat		Seasons											
		Fall			Winter			Spring			Summer		
		M	( $\chi^2$ )	F	M	( $\chi^2$ )	F	M	( $\chi^2$ )	F	M	( $\chi^2$ )	F
O													
N		31	(5.31*)	52	5	(1.66)	10	6	(0.09)	5	6	(-)	3
H		16	(3.27)	28	10	(0.66)	14	1	(-)	1	5	(-)	2
I													
N		29	(0.39)	34	2	(-)	1	9	(4.17*)	20	39	(3.04)	56
H		20	(1.06)	14	3	(-)	5	3	(-)	3	6	(0.40)	4
II													
N		15	(1.68)	23	2	(-)	1	48	(5.26*)	28	44	(0.01)	45
H		8	(0.80)	12	4	(-)	1	5	(1.14)	9	9	(0.20)	12
III													
N		2	(-)	1	5	(-)	1	25	(0.55)	20	14	(0.15)	12
H		2	(-)	2	1	(-)	0	2	(-)	3	4	(-)	1
IV													
N		5	(-)	2	2	(-)	0	15	(0.14)	13	23	(11.57**)	5
H		2	(-)	0	2	(-)	1	6	(-)	2	10	(10.00**)	0

\*P 0.05

\*\*P 0.01

A significant age group x season interaction ( $P=0.05$ ) was found in the natural temperature water where age group I, III and IV showed an increase in mean length from 72 to 81 mm, 129 to 145 mm, and 151 to 164 mm, respectively, from fall to winter. Age group II showed a slight decrease (110 to 109 mm) whereas age group O had a larger decrease (34 to 29 mm) during the same period. From winter to spring decreases were witnessed for mean length in age group I (81 to 60 mm), II (109 to 86 mm), III (145 to 126 mm) and IV (164 to 144 mm), and an increase was shown in age group O (29 to 34 mm). Increases were seen in age groups I (60 to 62 mm), II (86 to 101 mm), III (126 to 135 mm) and IV (144 to 149 mm), and age group O remained the same (34 mm) during the spring to summer period. The average length values of age group V were 146 mm in the fall, 157 mm in the spring and 156 mm in the summer. No five year old fish were collected from natural temperature water in the winter.

In the heated habitat interaction (age group x season) also was significant ( $P=0.05$ ) for the length (excepting age group III). From fall to winter mean length increases were seen in age groups O (35 to 42 mm), I (86 to 91 mm) and IV (149 to 156 mm). Only age group II showed a decrease (117 to 110 mm) during this period. Decreases were obvious in age groups O, I, II and IV as mean length values dropped from 42 to 35 mm, 91 to 56 mm, 110 to 95 mm, and 156 to 149 mm, respectively, from winter to spring. From spring to summer the mean length values for age groups O (36 mm) and IV (149 to 148 mm) were essentially constant whereas age groups I (56 to 73 mm) and II (95 to 108 mm) had increased values. Seasonal average length values (O when no fish were collected) for age groups III and V, respectively, were 130 mm and O in the fall, O and 162 mm in winter, 126 mm and 146 mm in spring, and 122 mm and 158 mm in summer.

In three separate age groups fish from the heated environment had significantly greater annual mean lengths than



their counterparts in ambient temperature waters (Table 3). Significant values were found in age group O (37 and 34 mm), males of age groups I (79 and 66 mm) and II (114 and 97 mm), and females of age group I (85 and 66 mm).

A two factor analysis of variance test (habitat x season) for length of redbreast sunfish, age groups O - IV, indicated greater mean lengths of fish from the thermal plume in age groups O and I as main effect habitat was significant ( $P=.05$ ). Additional t-tests indicated that significant differences ( $P=.05$ ) for mean length values existed in winter (43 and 29 mm) of age group O, and in fall (86 and 72 mm) and summer (73 and 62 mm) of age group I.

Average lengths of individuals in each age group from natural and heated environments were determined for each sex except in age group O where difficulty in identifying sex of individuals necessitated combining all data (Fig. 4 and 5). In each environment male and female fish of consecutive age groups II - IV had significantly greater annual mean lengths than specimens of the same sex of the previous age group (Table 3). Both sexes of age group I from both habitats had a significantly greater annual mean length than did fish of age group O in the corresponding habitat. In age groups III and IV from ambient temperature water annual mean lengths of males were significantly greater than those of females. Greater annual mean length of males also was seen in age groups II and III in the heated water.

#### DISCUSSION

The effect of seasonal changes on the abundance of redbreast sunfish in the ambient temperature water was pronounced as numbers of fish per collection decreased substantially in the winter and conversely reached their greatest numbers during warmer periods. Overwintering in deeper water is less common in fishes inhabiting rivers than those in reservoirs; however, it is probable that most riverine fishes move out from the bank in winter to avoid the varying temperatures of the shallower shore region (Nikolskii, 1963). As collections were made near the shore during the present study, either of these could account, at least in part, for the fewer numbers in the winter collections. Accordingly, warmer weather attracts fishes to the banks for reproduction and feeding activities (Breder and Rosen, 1966) thus making them more susceptible to collection.

Seasonal influences on abundance of redbreast sunfish were not as apparent in the artificially elevated temperature habitat. Here there was approximately equal abundance per collection in winter, spring, and summer with the only change being an increase in the fall. Although the redbreast sunfish has been one of the few species found in elevated water temperatures reaching 39 C in the James River (Woolcott, 1974), it generally avoided the highest temperatures of the thermal plume during the warmer months of summer. Only during winter did the abundance per collection in the thermal plume exceed that in ambient temperature habitat. It has been proposed by several authors (Trembley, 1960; Parker and Krenkel, 1969; Gammon, 1973) and documented by others, (Benda and Proffitt, 1974; Coutant, 1975) that fishes are attracted to the heated effluent of power stations, during the colder periods of the year. In the present study, however, it is believed that fish were not particularly attracted to the heated plume in the winter as there was a decline from the numbers collected in the fall, but rather mass migrations toward the deeper water from the fluctuating shoreline temperatures of the natural habitats contributed to the difference in winter numbers collected.

Several factors probably influenced the increase in occurrence and abundance of redbreast sunfish in collection periods of low river discharge. Those considered particularly

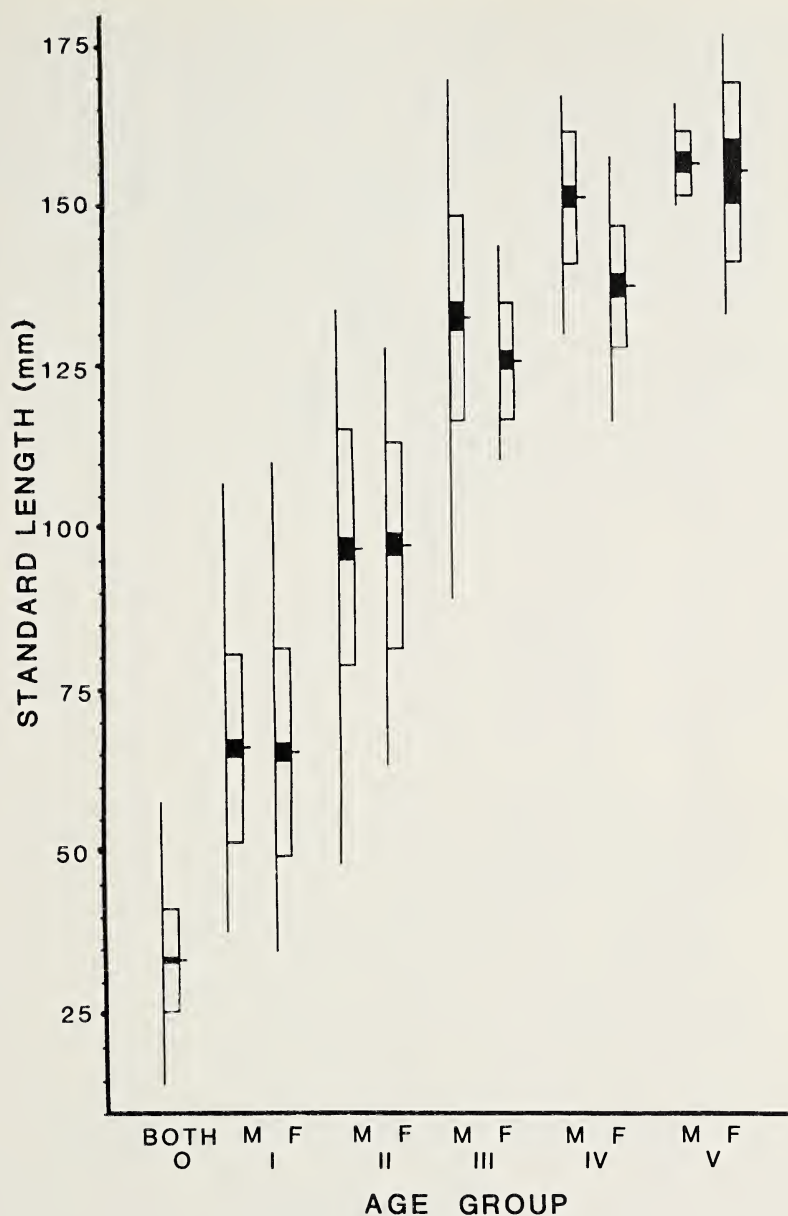
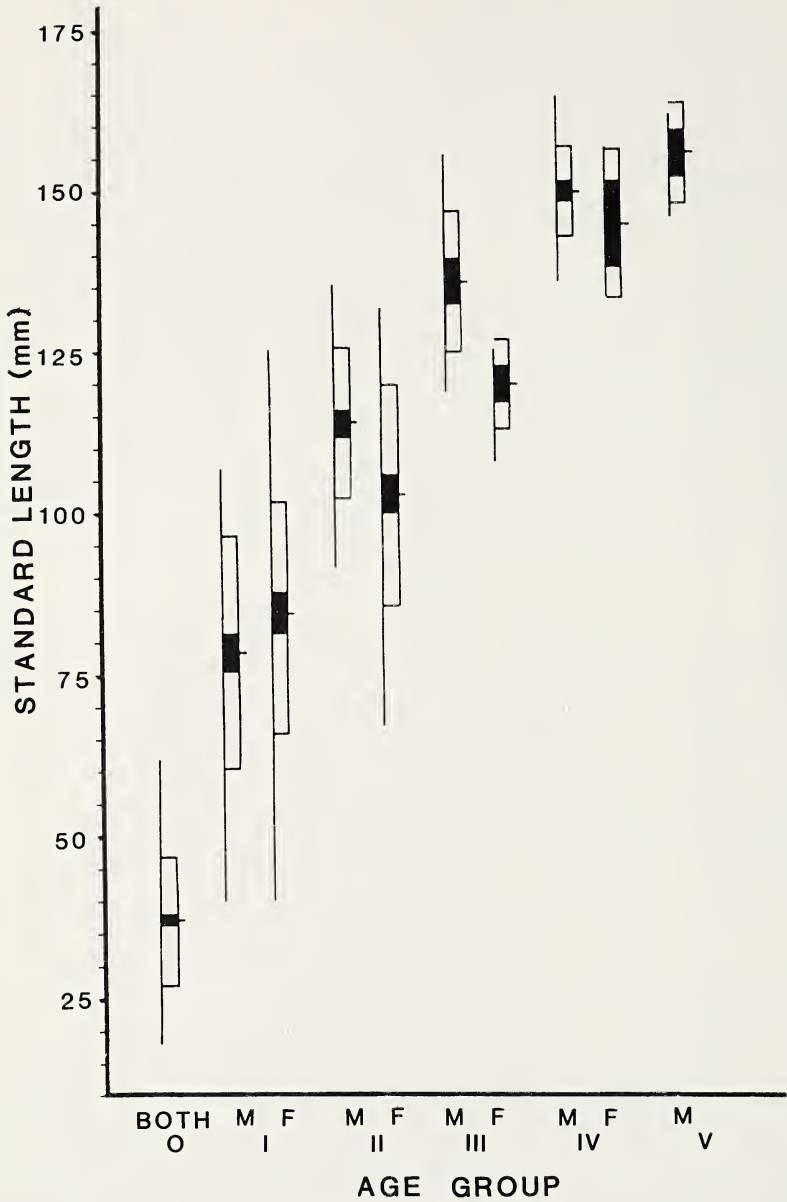


Figure 4.

A comparison of the standard lengths of male and female redbreast sunfish, age groups I-V (sexes combined in age group O), from ambient temperature habitats in the James River, near Bremono Bluff, Virginia (October 1971-September 1973). Range indicated by the vertical line; mean, by horizontal line; two standard errors of the mean, by black bar; and two standard deviations by the black bar plus the white bars.



**Figure 5.**  
A comparison of the standard lengths of male and female redbreast sunfish, age groups I-V (sexes combined in age group class O), from heated temperature habitats in the James River, near Bremono Bluff, Virginia (October 1971-September 1973). Graph legend as in Fig. 4.



significant were reduction in the number of available habitats near shore, shallowness and clarity of water and less chance for electrically stunned fish to be carried away by the decreased water current. Lagler (1970) states that the effectiveness of direct current electrofishing is influenced by turbidity and depth of the water, i.e. in the more turbid (although conductivity increases, specimens are more difficult to locate) and deeper water efficiency decreases.

The oldest specimens of redbreast sunfish in our study were five years old, which is less than that given for the species in other studies. Davis (1971) reported six year old fish from North Carolina; Sandow et al. (1975) gave seven as the oldest age for them in Satilla River, Georgia; and Carlander (1977) lists an eight year old specimen from Connecticut.

It is proposed that the sharp decline in numbers of James River redbreast sunfish between age groups II and III is associated with the behavior of larger fish, which do not characteristically frequent areas in the shallower water near shore to the same extent that younger smaller fish do and thus were not frequently exposed to the collection method employed in this study. Also, the increased body surface of larger fishes may enable them to detect the electric field at a greater distance and thus escape before the galvanotaxic response is imposed (Gammon, 1975).

High numbers of age group 0 fish from both habitats were attributed to the collecting procedures used during the first six months of the study when wading with electrodes in slow current backwater pools (the preferred habitat of young fishes) was used in conjunction with electrofishing from a boat. The percentage of these fish in collections from the heated side was almost twice that of the same age group from the ambient side, reflecting the more extensive backwater areas in the heated plume.

Seasonal composition by age group of the collections of redbreast sunfish from both habitats of this study can be related to reproduction and feeding cycles. Davis (1971) reported this species spawned in shallow water during late spring or early summer in North Carolina when water temperatures reached 22 - 26 C. Fecundity rates for fish in age groups II - VI were included in his study and as none were given for younger fish the implication is that redbreast sunfish do not reach sexual maturity until the age of two years. As most sexually mature fish of a given species have a similar breeding cycle, we could expect age groups II - V to have a similar reproduction cycle and appear in larger numbers during the spring and summer spawn and in fewer numbers during the colder months of winter, which was the case for fish in these age groups from both sides of the river. The appearance of greater numbers of age group 0 fish in the fall collections from both habitats probably was related to having attained a size large enough to be captured by the collecting gear used with the boat. Also, the previously mentioned wading method of collection in the shallower habitats during the first fall may have influenced the greater numbers of age group 0 during this season, just as it probably did the high percentages of this age group in the total sample populations. Sexually immature age group I fish, readily caught in the electrofishing nets, appeared in peak numbers during summer in the ambient temperature collections and during fall in those from heated water. Feeding activity near shore probably accounted for larger numbers of this age group during those seasons. In most age groups from both habitats winter abundance generally was lowest. Exceptions to this were seen in age group V fish from the heated water where abundance was relatively low throughout the year, and in year class 0 fish from both habitats where fish were too small to be captured effectively with the available collection gear during the spring and summer. It would seem that

even though migration is less extensive from the heated plume than from ambient temperature habitats in the winter, redbreast sunfish generally follow a pattern of migration into deeper water during colder periods.

The overall sex ratio was 1:1, but small numbers of redbreast sunfish in most seasonal collections precluded a complete analysis of sex ratio by season. Inadequate sampling is the only readily available explanation for the absence of females (age group IV) in the heated effluent during summer. Four different age groups in three different seasons in ambient temperature water demonstrated a significantly unbalanced sex distribution. The male dominance of age group II during spring and age group IV in the summer was probably the result of the availability of the nest guarding males to the sampling technique. Females in age group O in the fall and in age group I in the spring dominated the earlier age groups and males dominated the latter year classes. Schmittou (1967) found a similar condition in bluegill populations in three Alabama lakes.

In most temperate zone fishes growth ceases or decreases during the colder months of winter and resumes or increases in the spring (Tesch, 1970). No attempt was made to determine the seasonal growth rate of redbreast sunfish in the present study; however, it would appear from the seasonal mean lengths of each age group of both heated and natural habitats that growth began in spring as water temperatures and daylengths increased and continued until winter with the occurrence of short daylengths and lower water temperatures. The tendency for mean lengths of each age group to decrease in spring probably is related to the recruitment of a new size group from the previous age group as a new annulus formed. Pronounced deviations from this tendency, e.g. in fish of age group O from ambient waters during spring, may reflect the organization of the study. By dividing the year into the four calendar seasons, which may not coincide precisely with the seasonal growth pattern, fish from the previous year's spawn may not have formed their first scale annulus. Therefore, even though one year old, they were classified with age group O.

There was an increased mean length for fish (age groups O and I; males only in age group II) from the thermal plume over fish in the corresponding groups from the ambient waters. It has been established that temperature alters the rates of metabolic processes and may be expected to have considerable effect on the growth of poikilothermous animals (Phillips, 1969). Slower growth coincides with lower temperatures, with little or no growth below a certain temperature. Above this, the rate of growth should increase with temperature to a maximum and then decrease, perhaps becoming negative (weight) at temperatures approaching the lethal limits (Brown, 1957). According to O'Rear (1968), who studied growth in one and two year old redbreast sunfish in an environment receiving a heated discharge, there was no increased growth seen in fish from elevated water temperature habitats when compared to those from natural waters, yet results of several authors working with other species of fishes lend support to the belief that increased temperatures do have an influence on growth rates. A review by Phillips (1969) stated that Schauperclaus (1933) found the rate of metabolic activities of fishes doubled with a 10 C rise in water temperature. Fry and Hart (1948) reported that over a range of 5 - 35 C, standard metabolism for goldfish (Crassius auratus) increased to its highest value at about 30 C. It then remained steady or decreased slightly at temperatures higher than 35 C. In a study on the growth of largemouth bass (Micropterus salmoides) fry kept at various temperatures, Strawn (1961) found they grew at a greater rate at 27.5 - 30 C than at temperatures above or below those.

There are several possible explanations for redbreast sunfish from heated habitats having increased annual mean lengths



only in age groups O, I and II. For one, metabolic rates of small fishes are greater than those of larger fishes because of larger body surface/volume ratio (Schauperclaus, 1933). Lattimore and Gibbons (1976) compared the condition of three sunfish species (including redbreast sunfish) in natural and thermally influenced streams in South Carolina and found fish in natural temperatures, but near elevated temperature water, to have higher body condition factors than those from other areas. They concluded these fishes could take advantage of the nutrient rich warmer water without expending greater energy that would be required in the heated habitat. Brown (1957) stated that when fishes spend their whole lives in one environment, their growth rates generally decline progressively as they grow older. In addition Lewis et al. (1974) gave evidence that the percentage of body weight which the stomach contents comprised in largemouth bass was greater in smaller fish than larger fish, demonstrating that small fish frequently consume a greater daily ration in proportion to their body weight.

Male redbreast sunfish were significantly longer than females in age group III and IV in the natural environment and in age group II and III in the heated habitat. Unfortunately, no studies pertaining to sexually related growth rates for the species could be found for comparison, and sexual growth rates reported for other *Lepomis* species are contradictory. Larimore (1957) reported male warmouth sunfish (*Lepomis gulosus*) to be larger than females in year classes I - V. Schmittou (1967) found male bluegill grew faster than females, and Di Costanza (1957) reported male bluegills to be larger than females in the third and fourth years of life. Agreeing with Di Costanza, Sprugel (1954) found male bluegill grow more rapidly between the first and fourth years of life in midwestern lakes. Hubbs and Cooper (1935) pointed out that among centrarchids males usually grow faster than females. On the other hand, Beckman (1949) was unable to distinguish any significant difference in growth for either sex of bluegill, and Morgan (1951) obtained results indicating a faster growth rate for females in this species. If there is a greater growth rate for male redbreast sunfish, then this in conjunction with an increased growth rate associated with increased water temperature might account for the male length dominance showing up in an earlier age group (II) in the heated habitat. These accelerated growth rates also might account for only male redbreast sunfish of age group II from heated habitats demonstrating significantly greater annual mean lengths than their counterparts in the ambient water habitats.

In summary, redbreast sunfish from the James River have a sex ratio and growth pattern similar to those reported for the species in studies of other rivers in Southeastern United States. They are, however, shorter lived. Since the area affected by the heated discharge from the power plant was so limited its effect on the ecosystem was minimal. Seasonal influence, although not as pronounced in the heated habitat as in the ambient temperature water, was an important factor in the seasonal composition of age groups in both habitats because of its relation to reproduction and feeding activities. The greatest differential in mean annual lengths of fish from the two habitats was in age groups O and I and age group II males where greater mean lengths occurred in the heated water.

Results from this study should prove useful when added to the data base on James River fishes that will evolve from the investigation of the James River ecosystem now underway by the Virginia Commission of Game and Inland Fisheries.

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## LITERATURE CITED

- Beckman, W. C. 1949. The rate of growth and sex ratio for seven Michigan fishes. *Trans. Am. Fish. Soc.* 76 (1946): 63-81.
- Benda, R. S., and M. A. Proffitt, 1974. Effects of thermal effluents on fish and invertebrates. Pages 438-447 in J. W. Gibbons and R. R. Sharitz, eds., *Thermal Ecology*, U. S. Atomic Energy Commission, Washington, D. C.
- Bishop, O. N. 1966. *Statistics for Biology*. Houghton Mifflin Co., Boston, MA.
- Breder, C. M., Jr. and R. F. Nigrelli. 1935. The influence of temperature and other factors on the water aggregation of the sunfish *Lepomis auritus* with critical remarks on the social behavior of fishes. *Ecology* 16 (1): 33-47.
- \_\_\_\_\_ and D. E. Rosen. 1966. Modes of Reproduction in Fishes. *Nat. Hist. Press*, NY.
- Brown, M. E. 1957. *The Physiology of Fishes*, Vol. I. Acad. Press, Inc., NY.
- Carlander, K. D. 1977. *Handbook of Freshwater Fishery Biology*; Vol. 2. Iowa State Univ. Press, Ames, IA.
- Coutant, C. C. 1975. Responses of bass to natural and artificial temperature regimes. Pages 272-285 in M. Cleppes, ed., *BlackBass Biology and Management*. Sport Fishing Institute, Washington, D. C.
- Clugston, J. P. 1973. The Effects of Heated Effluents from a Nuclear Reactor on Species Diversity, Abundance, Reproduction, and Movement of Fish. Ph.D. Thesis, Univ. GA. Diss. Abst. Int. 34 (8) B: 3580.
- Davis, J. R. 1971. The spawning behavior, fecundity rates, and food habits of the redbreast sunfish in southeastern North Carolina. *Proc. 25th Ann. Conf. S. E. Assoc. Game and Fish Comm.*: 556-560.
- Di Costanza, C. J. 1957. Growth of bluegill, *Lepomis macrochirus*, and pumpkinseed, *L. gibbosus*, of Clear Lake, IA. *Iowa St. Coll. J. Sci.* 32 (1): 19-34.
- Fry, F. E. J., and J. S. Hart. 1948. The relation of temperature to oxygen consumption in goldfish. *Biol. Bull.* 94: 66-77.
- Gammon, J. R. 1973. Completion report: The effect of thermal inputs on the populations of fish and macroinvertebrates in the Wabash River. *Purdue Univ. Water Resour. Res. Ct.*, West Lafayette, Inc. Unpub.
- \_\_\_\_\_. 1975. Distribution and abundance of fish populations in the middle Wabash River. *Depauw Univ.* Unpub.
- Hayslett H. T., Jr. 1968. *Statistics Made Simple*. Doubleday and Co., Inc. Garden City, NY.
- Hubbs, C. L. and G. P. Cooper. 1935. Age and growth of the longear and green sunfishes in Michigan. In *Growth of bluegill, Lepomis macrochirus, and pumpkinseed, L. gibbosus, of Clear Lake, IA*. C. J. Di Costanza. *Iowa St. Coll. J. Sci.* 32 (1): 19-34.
- Kirk, W. L. 1974. Study area. In *The effects of thermal loading by the Bremo Power Station on a Piedmont section of the James River*. W. S. Woolcott (Prin. Investigator). Tech. Rept. for VEPCO. VA. Inst. Sci. Res. 2 Vols.: 17-86.
- Lagler, K. F. 1956. *Freshwater Fishery Biology*. W. C. Brown Pub. Co., Dubuque, IA.
- \_\_\_\_\_. 1970. Capture, sampling and examination of fishes. In *Methods of Assessment of Fish Production in Fresh Waters*. W. E. Ricker (Ed.). Blackwell Sci. Publ., Oxford: 7-45.

- Larimore, R. W. 1957. Ecological life history of the warmouth (Centrarchidae). III. Nat. Hist. Surv. Bull. 27(1): 1-83.
- Lattimore, R. E. and J. W. Gibbons. 1976. Body condition and stomach contents of fish inhabiting thermally altered areas. Am. Midl. Nat., 95(1): 215-219.
- Lewis, W.M., R. Heidinger, W. Kirk, W. Chapman and D. Johnson. 1974. Food intake of the largemouth bass. Trans. Am. Fish. Soc. 103(2): 277-280.
- Morgan, G. D. 1951. The life history of the bluegill sunfish, Lepomis macrochirus, and pumpkinseed, L. gibbosus, of Clear Lake, IA. C. J. Di Costanza, Iowa St. Coll. J. Sci. 32(1):19 - 34.
- Nikolskii, G. V. 1963. The Ecology of Fishes. Acad. Press, NY.
- O'Rear, R. S. 1968. A growth study of redbreast, Lepomis auritus (Gunther), and bluegill, L. macrochirus (Rafinesque), populations in a thermally influenced lake. Proc. 23rd Ann. Conf. S. E. Assoc. Game and Fish Comm.: 545-553.
- Parker, F. L. and P. A. Krenkel (Eds.). 1969. Thermal Pollution: Status of the Art. Dept. Environ. Water Resour. Engineer. Vanderbilt Univ. Press, Nashville, TN.
- Phillips, A. M., Jr. 1969. Nutrition, digestion and energy utilization. In Fish Physiology, Vol. I. W. S. Hoar and D. J. Randall (Eds.). Acad. Press, NY.: 391-432.
- Raney, E. C. 1950. Freshwater fishes. In The James River Basin; Past, Present and Future. Va. Acad. Sci., Richmond, VA:151-194.
- Sandow, J. T., Jr. and D. R. Holder and L. E. McSwain. 1975. Life history of the redbreast sunfish in the Satilla River, Georgia. Proc. 28th ANN. Conf. S. E. Assoc. Game and Fish Comm.: 279-295.
- Schauperclaus, W. 1933. Textbook of Pond Culture. U. S. Fish Wildlife Serv., Fish. Leaflet 311.
- Schmittou, H. R. 1967. Sex ratios of bluegills in four populations. Trans. Am. Fish. Soc. 96(4): 420-421.
- Sprugel, G., Jr. 1954. Growth of bluegills in a new lake with particular reference to false annuli. Trans. Am. Fish. Soc. 83(1953): 58-75.
- Steele, R. G. and J. H. Torre. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., Inc. NY.
- Strawn, K. 1961. Growth of largemouth bass fry at various temperatures. Trans. Am. Fish. Soc. 90(3): 334-335.
- Tesch, F. W. 1970. Age and Growth. In Methods for Assessment of Fish Production in Fresh Waters. W. E. Ricker (Ed.). Blackwell Sci. Publ., Oxford: 93-123.
- Trembley, F. S. 1960. Research project on effects of condenser discharge water on aquatic life. Progress Report, 1956-59. The Inst. of Res., Lehigh Univ. Unpub.
- Walpole, R. E. and R. H. Meyers. 1972. Probabilities for Engineers and Scientists. Macmillan Co., NY.
- Woolcott, W. S. 1972. The effects of thermal loading by the Brems Bluff Station on a Piedmont Section of the James River. Progress Report. VA. Inst. for Sci. Res., Unpub.
- \_\_\_\_\_. 1974. Fishes. In The Effects of Thermal Loading by the Brems Bluff Station on a Piedmont Section of the James River. W. S. Woolcott (Prin. Investigator). Tech. Rep. for VEPCO. VA. Inst. for Sci. Res. 2 Vols.: 421-543.

## Effects of Food Restriction on Body and Organ Weights and Cardiac Function in Obese/Overweight Rats

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### ABSTRACT

Fifteen obese/overweight (ob/ow) adult male rats were used to assess the effects of food restriction on body weight (bw), organ weight and hemodynamic functions. The rats were assigned randomly into three groups of five rats each. In Group A, rats were fed ad libitum. In Group B and C, rats were allowed 15 and 5 grams of food per day, respectively. After 8 weeks of food rationing the rats were anesthetized, and their blood pressure and heart rate were measured. Then the animals were killed and the weight of each heart, lung, liver, spleen, kidney, testicle, stomach and brain was measured. As expected, the degree of change in weights of most major organs did correspond with the body weight changes and food rationing, with the exception of the stomach and the brain which were unaffected. In addition, the present study demonstrated that only rats fed 5 gm/day had significantly lower blood pressure and heart rate than control rats fed ad libitum. These results suggest that prolonged severe food restriction in the treatment of the obese and the overweight may result in adverse effects on functional and structural changes in many organ systems.

Key words: Obesity/Overweight; Food restriction; Blood pressure and heart rate; Body and organ weights; rats.

Obesity is recognized as a major health problem in Western Society (Mann, 1974). Epidemiological studies indicate that excessive weight is often associated with an increased prevalence of coronary heart disease, diabetes mellitus and systemic hypertension (Van Itallie, 1977). While genetic, hormonal and metabolic factors may play an etiological role in the development of obesity; excessive food ingestion and reduced physical activity definitely will result in gross overweight and obesity.

The treatment of obese/overweight patients usually consist of caloric restriction (reduction of food intake) and/or increase of energy expenditure (exercise). Prolonged starvation in normal persons frequently has adverse effects on functional and structural changes in many organ systems (Keys *et al.*, 1950). The present study was undertaken to assess the effects of food restriction on body organ weight loss, and cardiac function in sedentary adult obese/overweight male rats.

### METHODS

Fifteen one year old male Sprague-Dawley rats weighing 550-700 grams were selected from the Virginia Tech Animal Facilities for this study. Only male rats were used in our experiment because they respond more quickly to the stress of starvation (Widdowson, 1976). The rats were housed individually in a controlled environment ( $22 \pm 1^\circ\text{C}$  and  $50 \pm 10\%$  humidity) with a 12 hour light-dark cycle. The animals had free access to water at all times during



Table 1. Effects of food restriction on body weight of obese/overweight male rats.

Body weight (gms)			
Time	Ad libitum* (N=5)	15 gm/day (N=5)	5 gm/day (N=5)
Control	610.0 ± 20.7	600.0 ± 14.1	640.0 ± 12.0
After 8 weeks	592.0 ± 11.2	460.0 ± 8.9	283.0 ± 9.4
P	NS	< 0.001	< 0.001

Values are mean  $\pm$  SE. \*The average food intake during 8 weeks experimental period was  $36.7 \pm 2$  gm. N = number of animals.

the experiment, and varying amounts of Purina Rat Chow. The rats were randomly divided into 3 groups of 5 rats each. In Group A (controls), the food was offered to them ad libitum throughout the entire experimental period. Group B and Group C rats were allowed 15 gm and 5 gm of food per day, respectively. The food intake of the control rats was determined daily by offering 50 gm and weighing the amount remaining the next day. The average food intake during the 8 weeks experimental period in control ad libitum animals was  $36.7 \pm 2.7$  gm/day. All rats were weighed at weekly intervals and carefully observed for the general state of well-being.

After the 8 weeks experimental period, the rats were anesthetized by an intraperitoneal injection of sodium pentobarbital (30 mg/kg). Body temperature was maintained at  $37^{\circ} \pm 1$  C with a heating pad. The left common carotid artery was cannulated with a polyethylene catheter (PE 50) for measuring blood pressure and heart rate. The arterial blood pressure was measured with a Sanborn transducer and Grass Polygraph system (Model 7). The heart rate was obtained from the arterial pulse pressure trace. The right jugular vein was cannulated with polyethylene tubing for infusions.

After completion of arterial blood pressure and heart rate measurements, each rat was quickly killed by an overdose of sodium pentobarbital. The organs were immediately excised and cleaned of blood by flushing with saline, and the excess moisture was removed with paper towels. All extraneous fat on the organ was carefully removed. The organs were weighed separately on an electronic balance sensitive to 0.01 gm (Fisher Model 8204).

The data were analyzed using Duncan's New Multiple Range test to identify significant differences among the various pairs of variables; and the F-ratio was determined by one-way analysis of variance. Differences were considered significant when the p value was less than 5% (Krammer, 1956; Snedecor and Cochran, 1967).

## RESULTS AND DISCUSSION

There is considerable information about the effects of malnutrition and starvation in the development of normal young and adult humans and animals. In contrast, the anatomical adaptations that occur in adult obesity during starvation are poorly documented. The weight loss process in overweight/obese individuals often leads to a number of medical and psychological complications. The results of this study illustrate that the impact of severe food restriction in overweight/obese adult rats also had a significant effect on body weight, organ weights, and in the hemodynamic functions.

Table 1 shows the initial body weight and the body weight following 8 weeks

Table 2. Arterial blood pressure and heart rate of obese/overweight rats after 8 weeks of different food rations.

Group	N	Heart rate (beats/min)	Arterial blood pressure (mmHg)		
			Systolic	Diastolic	Mean
Ad libitum	5	378.8	164.5	132.0	143.3
		± 20.8	± 5.9	± 6.9	± 6.5
15 gm/day	5	326.3	181.5	151.3	161.3
		± 18.7	± 11.7	± 12.3	± 12.3
5 gm/day	5	262.0*	132.6*	102.0*	111.8*
		± 19.1	± 9.7	± 7.6	± 8.2

Values are mean ± SE. N = number of animals. \*Statistical significance at  $P < 0.001$  level.

of experimental food rationing in sedentary overweight adult rats. During the experimental period, the average food intake of the ad libitum group rats was 36.7 (± 2.7) gm/day. The average body weight of this group of rats remained relatively constant at about 600 gm throughout the experimental period. In contrast the rats restricted to 15 or 5 gm/day lost about 20 and 60% of their original body weight, respectively. These changes were highly significant ( $P < 0.001$ ). Thus, the degree of change in body weight of overweight/obese adult rats is determined by the magnitude of food restrictions.

Table 2 summarizes the influence of food rations on the arterial blood pressures and heart rate of overweight/obese rats. No significant differences in the mean arterial blood pressure and heart rate were observed between rats fed ad libitum and 15 gm/day; however, both blood pressure and heart rate were significantly lower in the animals fed 5 gm/day than the 15 gm/day and ad libitum fed rats ( $P < 0.001$ ).

Marked obesity seems always associated with significant alterations in cardiovascular function. High blood pressure is one of the constant findings in human obese patients. The weight reduction in hypertensive obese human patients may be accompanied by a fall in blood pressure, often to normal levels with little change in heart rate (Alexander and Peterson, 1972; Alpert *et al* 1985; Martin, 1952). However, with excessive weight loss (a 25% decrease in body weight), particularly when achieved by semistarvation, the hypotension is usually associated with bradycardia. Sinus bradycardia has also been observed in obese rats fed a liquid-protein diet (Anderson *et al*, 1981). The mechanism which causes the decrease in heart rate with malnutrition is unclear.

Table 3 shows the weights of most organs in overweight/obese rats did change in correspondence with the body weight and the food ration of the animal (Table 3). It is interesting to note that the wet lung weight was significantly higher in rats fed 5 gm/day compared to ad libitum fed rats. This may be a reflection of severe malnutrition and pulmonary edema in rats fed 5 gm/day. In contrast, Sahebhami and MacGee (1985) recently showed that adult prolonged partial food deprivation in normal rats resulted in a loss in both body and lung weight, but had no significant effects on lung mechanics and connective tissue. On the other hand, the results of this study show that severe food restriction has no effects on the weights of brain and stomach in rats (Table 3). These observations are consistent with previous data collected in starving humans during World War II (Keys *et al*., 1950). They had large losses in heart, liver, kidney, and spleen weights but no change in the brain. It is interesting to note that prenatal malnutrition has profound effects on the development of nervous function in growing rats but the brain weight of the young rats were essentially identical between feed-restricted

Table 3. Effects of food restriction on body and organ weights of adult obese/overweight male rats.

WEIGHT (GRAMS)												
Group	N	BW	Heart	Lung	Liver	Spleen	Kidney		Testicle		Stomach	Brain
							Left	Right	Left	Right		
Ad libitum	5	592.0 ± 11.2	1.54 ± 0.02	2.22 ± 0.23	18.85 ± 0.88	1.14 ± 0.05	2.15 ± 0.05	2.20 ± 0.06	1.88 ± 0.03	1.84 ± 0.04	2.46 ± 0.08	2.14 ± 0.08
15 gm/day	5	460.0 ± 8.9	1.46 ± 0.01	2.48 ± 0.46	14.78 ± 1.08	0.77 ± 0.03	2.00 ± 0.02	1.99 ± 0.04	1.74 ± 0.05	1.76 ± 0.06	2.50 ± 0.04	2.17 ± 0.08
5 gm/day	5	283.0 ± 9.4	1.15 ± 0.03	3.56 ± 0.38	7.73 ± 0.65	0.41 ± 0.03	1.66 ± 0.08	1.69 ± 0.07	1.38 ± 0.07	1.34 ± 0.07	2.36 ± 0.08	2.16 ± 0.05
P*		< 0.001	< 0.001	NS	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NS	NS

Values are mean ± SE. N = number of animals. BW = body weight. \*Levels of statistical significance (F test).



and control group at birth (Resnick, et al., 1979). More recently, Pond et al. (1986) reported that severe feed restriction produced no reduction in weights of stomach, small and large intestines of both adult and growing rats. Why are brain and stomach relatively more resistance to atrophy in malnutrition and starvation? The physiological and biochemical bases for these responses need further investigation.

In summary, prolonged severe food restriction was an effective means to reduce overall body weight in obese/overweight rats. One of the mechanisms at play appears to be a decrease in organ weights that may be quite distinct from loss of adipose mass. These changes in organ weights, in relation to the underlying pathophysiological disturbance in semistarvation (undernutrition), will require more detailed studies at the functional and biochemical levels.

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#### LITERATURE CITED

- Alexander, J.K. 1985. The cardiomyopathy of obesity. *Prog. in Cardio. Dis.* 28:325- 334.
- Alexander, J.K. and Peterson, K.L. 1972. Cardiovascular effects of weight reduction. *Circulation* 45:310-318.
- Alpert, M.A., Terry, B.E., Kelly, D.L. 1985. Effect of weight loss on cardiac chamber size, wall thickness and left ventricular function in morbid obesity. *Am. J. Cardiol.* 55:783-786.
- Anderson, Y.A., Ahn, P.C. and Hegarty, P.V.J. 1981. Electrocardiographic abnormalities in obese rats fed a commercially available liquid protein diet. *J. Nutr.* 111:568-578.
- Keys, A., Brozek, J., Henschel, A., Michelsen, O. and Taylor, H.L. 1950. *The Biology of Human Starvation.* The University of Minnesota Press, Minneapolis.
- Krammer, C.Y. 1956. Extension of multiple range tests to group means with unequal number of replication. *Biometrics* 12:307-310.
- Mann, G.V. 1974. The influence of obesity on health. *N. Engl. J. Med.* 271:178-185.
- Martin, L. 1952. Effect of weight-reduction on normal and raised blood pressures in obesity. *Lancet* 2:1051-1053.
- Pond, W.G., Yen, J.T. and Mersmann, H.J. 1986. Response of the gastrointestinal tract of rats to severe restriction of diet or of nonprotein calories. *Nutr. Rep. Inter.* 33:831-842.
- Resnick, O., Miller, M., Forbes, W., Hall, R., Kemper, T., Bronzino, J. and Morgane, P.J. 1979. Development protein malnutrition: Influences on the central nervous system of the rat. *Neuro. and Biobehav. Rev.* 3:233-246.
- Sahebajani, H. and MacGee, J. 1985. Effects of starvation on lung mechanics and biochemistry in young and old rats. *J. Appl Physiol.* 58:778-784.
- Snedecor, G.W. and Cochran, W.G. 1967. *Statistical Methods* 6th ed. Iowa State University Press. Ames, IA.
- Van Itallie, T.B. 1977. Obesity: Prevalence and pathogenesis. In: *Diet Related to Killer Disease. II Hearings before Select Committee on Nutrition and Human Needs.* United State Senate, Washington, D.C., United States Government Printing Office, pp. 47-64.
- Widdowson, E.M. 1976. The response of the sexes to nutritional stress. *Proc. Nutr. Soci.* 35:175-180.

## Staffing Analysis and Volume Evaluation for Small Post Offices<sup>1</sup>

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### ABSTRACT

For one week in July 1976, data were obtained from 18 second- and 31 third-class post offices in southwest Virginia as potential indices of operating efficiency. Effects of seven independent variables on total staffing hours budgeted were examined using the method of least squares. Results were subsequently used to implement changes in the operating procedures of those units with low scores.

### INTRODUCTION

All businesses, including those operated by the government, must recognize basic considerations of efficient operation. Toward this objective, the U. S. Postal Service has made several changes over the past 20 years. These include changing the primary means of transportation from railroad to highway and air; a centralization of processing mail to better utilize mechanization; mathematical modeling of work load and staffing requirements in larger facilities on a closer real-time basis; acquisition, development and utilization of a comprehensive bank of time-study data for work measurement; increased flow of quantified management information; and, finally, the favorable impact of more automated mail processing equipment capable of reading addresses and affixing a bar code for further automated sortation. This has reduced manpower needed for subsequent sorting by streets, business or residences.

The present report contains an analysis of staffing and operating efficiency among 18 second class and 31 third class post offices in the Roanoke (VA) area. Its purpose was to examine quantifiable traits that could be used to estimate the relative effectiveness of manpower utilization in small post offices. The Sectional Center Management wanted guidelines for allocating budgeted hours by post office other than by requested hours based on historical usage.

### METHODS and MATERIAL

The Roanoke, Virginia area was selected for the present investigation, conducted in July 1976. A total of 49 second and third class post offices was included. From previous analyses of seasonal peaks in workload, the month of July was selected as a period of low volume work to minimize interference with working live mail. This low volume of mail occurs traditionally in July, shown in Figure 1 with an arrow.

Variables chosen for the study were:

1. Number of window service transactions.
2. Amount of originating non-local outgoing mail by types-- letters, flats, small parcels and rolls, and parcel post.
3. Number of pieces of mail cancelled with a local postmark;
4. Amount of destination or incoming mail by types;

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Table 1. Means by class of post office, and standard deviations, across and within classes, for variables in the study.

Variable		Time unit	Mean			Std. deviation	
			Post Office			Across groups	Within groups
Code	Name		Class 2	Class 3	Ave.		
X <sub>1</sub>	Window transactions	da.	176	60	102	92.5	74.2
X <sub>2</sub>	Outgoing volume	da.	1324	298	675	669.4	450.0
X <sub>3</sub>	Cancelled letters	da.	838	278	484	406.1	304.1
X <sub>4</sub>	Incoming vol.	da.	3679	1243	2138	1653.9	1164.1
X <sub>5</sub>	Rural carrier hrs.	da.	86	36	54	46.8	40.5
X <sub>6</sub>	Boxes rented	da.	268	68	141	137.9	98.5
Y	Clerk hours	wk.	101	49	68	30.4	16.6

Table 2. Regression estimates from least squares analyses. Roanoke Area Mail Study, 1976.

Variable		Partial regr'n.	t <sup>a</sup> for H:0		Rank <sup>c</sup>
Code	Name			p <sup>b</sup>	
b <sub>0</sub>	Intercept	75.378	----	-----	-
X <sub>1</sub>	Window transctions	0.064	2.25	.030	5
X <sub>2</sub>	Outgoing volume	0.004	0.76	0.454	7
X <sub>3</sub>	Cancelled letters	-0.018	-2.43	0.020	4
X <sub>4</sub>	Incoming volume	0.014	4.90	0.001	1
X <sub>5</sub>	Rural carrier hour	-0.121	-1.86	0.070	6
X <sub>6</sub>	Boxes rented	0.045	2.87	0.006	3
X <sub>7</sub>	Size Post Office	-14.159	-2.92	0.006	2

<sup>a</sup> t-value, H:0 = that parameter is zero.

<sup>b</sup> P = probability of Type I error.

<sup>c</sup> Rank in relative importance on final index.

5. Number of hrs used per week for each rural route;

6. Number of lock boxes rented;

7. Class or size of post office; and,

8. Total staffing hours, i.e., clerks, supervisors and postmaster, for each post office, budgeted each week.

The data cited above were then subjected to a series of multiple regression analyses of the form:

$Y = b_0 + b_1x_1 + b_2x_2 + \dots + b_nx_n$  (Snedecor and Cochran, 1967). The analyses were done using the SAS package of statistical programs, (Barr et al., 1976) with the Va. Tech computer, an IBM 370/158.

## RESULTS and DISCUSSION

Arithmetic means for all variables in the study are shown in table 1 by class of post office. Also shown are values for the standard deviations, calculated across classes, and within. Clearly, there are large differences be-



Table 3. Sample postal data, observed and predicted, from six post offices, three of each class, from the Roanoke (VA) area, 1976.

Office Location	Independent variables							Dependent variables		
	Daily window trans.	Daily outg'g volume	Daily cancel'n volume	Daily incom'g volume	Carrier hours per wk.	P. O. boxes rented	Class of	Clerk hours/week		
	$X_1$	$X_2$	$X_3$	$X_4$	$X_5$	$X_6$	P. O.	Observed	Predicted	Deviation
								$Y$	$\hat{Y}$	$Y - \hat{Y}$
Fieldale	217	1,597	702	3,466	45	616	2	143	125.3	17.7
Fincastle	167	1,078	1,039	3,666	78	173	2	101	92.5	8.5
Troutville	157	1,498	1,250	6,035	141	197	2	102	116.0	-14.5
Patrick Spgs	89	493	381	1,914	49	129	3	46	56.6	-10.6
Ripplemead	61	217	185	525	0	98	3	46	46.1	0.1
Spencer	59	326	309	1,190	40	86	3	50	47.8	2.2

Table 4. Conversion of regression values to measures of efficiency: A sample application, using observed data for Fincastle, VA.

Variables			
Code	Name	Hrs/wk <sup>a</sup> per daily occurrence	Obs. val. <sup>b</sup> av. daily frequency
C	Constant	4.58	1
X <sub>1</sub>	Av. window transactions possible per day	0.0643	167
X <sub>2</sub>	Av./day outgoing pieces (Weighted, 1338/hr)	0.0041	1,078
X <sub>3</sub>	Av./day cancellations (-303 pcs./hr)	-0.0182	1,039
X <sub>4</sub>	Av./day incoming vol. (weighted, 397 pcs./hr)	0.0139	3,666
X <sub>5</sub>	Carrier hrs/wk, ( -1.3235 min./carrier hr)	-0.1213	78
X <sub>6</sub>	Lock boxes rented (.4955 min/box; 121 bx/hr)	0.0454	173
X <sub>7</sub>	Class Post Office Size <sup>c</sup>	14.1594	3
TOTAL EXPECTED OFFICE HOURS PER WEEK:			
Scheduled office hours per week		101	
for Clerks, Supervisors and Postmaster		101	
Staffing efficiency = (Expected hours/Scheduled hours) X 100 = 91.6%		92.52	

<sup>a</sup> Regression values; see Table 2.

<sup>b</sup> Actual data; see Table 3.

<sup>c</sup> Note: 4th Class=1; 3rd Class=2; 2nd Class=3; 1st Class=4.

tween classes in the means for most variables. Workloads of the second class post offices were from two to four times as large as those of the third class offices. Information on the standard deviations shows that by restricting the analysis to data from post offices of the same general size, class two and class three, handled separately, the within-class variation was reduced by 15 to 50 percent.

Table 2 shows the partial regression coefficients (b-values), their respective t-tests, and their relative ranking. One additional window transaction ( $X_1$ ) per day would translate into 5.5 transactions in a 44-hour week, and would be expected to increase the weekly clerk-hours (Y), by 0.0643 hr, or 3.9 minutes. On a daily basis, this represents the 0.71 minutes, or 43 seconds per window transaction. Outgoing volume,  $X_2$  was the only variable that was not significant at  $P < 0.10$ . This was expected, since associate post offices (Classes 2 and 3) do not work world-destinating outgoing mail. This was specified as a prior constraint in selecting the post offices for the study.

The negative regression,  $b_3$ , shows that an increase in cancelled letters reduces total clerk hours required. This is due to "turn around mail", so-called because it never leaves the local post office's service area. Such work provides positive activity for what would otherwise be slack time for window clerks in second and third class post offices. The negative coefficient emphasizes a credit effect on the overall operating efficiency, since (1) locally destined mail is cancelled, separated and withheld from that routinely processed by the area distribution center; and, (2) the remaining pre-cancelled mail saves the need for its cancellation at the area distribution center, increasing overall efficiency there as well.

Incoming mail,  $X_4$ , was the most important single factor affecting clerical time required.

As rural carrier hours,  $X_5$ , increased the net effect on clerical time in the local post office was reduced. This is simply due to transfer, or extension of window-type service provided by the rural carrier to the rural boxholder.

Table 3 presents actual data for  $X_1$ -- $X_7$  and Y, from four post offices, the predicted staffing hours and the differences between observed and predicted staffing hours; and, the differences between observed and predicted values. The latter, predicted hours, was calculated using the regression values in Table 2. Negative values identify the more efficient post offices.

Table 4 contains an effort to interpret and apply the results for the regression values shown in Table 2. Those estimates were modified to reflect the weekly impact on staffing needs. An efficiency value was constructed for each post office as the ratio of staffing hours predicted divided by staffing hours observed (budgeted). This value, when less than unity, represented offices with efficiency less than average.

Data from the Fincastle Post Office were used to provide the example presented in Table 4, using regression values from Table 2. This technique has been used to provide patterns of general trends and to reallocate annual budgeted staffing hours for a number of post offices in Southwest Virginia.

#### LITERATURE CITED

- Barr, A. J., J. H. Goodknight, J. P. Sall and J. T. Helwig. 1976. Guide to SAS76. SAS Institute, Raleigh, N.C.
- Rowe, L. A. 1978. U. S. Postal Service: Historical Index Performance, "HIP". A daily workload measurement of clerk hours required based on historical data in Post Office, Harrisonburg, Virginia. Unpublished.
- Rowe, L. A. 1981. U. S. Postal Service Facility Space Requirements based on dissipating mediums (window service units, lockboxes and carriers): Management Sectional Center, Roanoke, Virginia.
- Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods for Research Workers. Sixth Edition; Iowa State University Press, Ames.
- U. S. Postal Service. 1970. Methods Handbook, M-65: Workload Recording System Weighting Factors, Organization and Management Division, Operations Department, Washington, D. C.



## Transposon Derived Mutants of *Bradyrhizobium japonicum* with Improved Nitrogen Fixation and Competitive Abilities on Soybean

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### ABSTRACT

Symbiotic mutants of USDA *Bradyrhizobium japonicum* (Jordan, 1982) strain I-110 were generated by introduction of Tn5 via conjugation (*E. coli* 1830) of the transposon suicide vector PJB4J1. Kanamycin resistant ( $Km^r$ ) clones were identified as Tn5 mutants by the criteria of altered phenotype and demonstration of the Tn5 insert by colony hybridization with Tn5 DNA. One thousand clones were screened on soybeans (*Glycine max* (L) Merr., 'Forrest') for altered nodulation (nod) and nitrogen fixation (fix). Symbiotic (nod, fix) mutants occurred at a frequency of 1.8% (18 clones of 1000 screened). Five mutants were identified with the highest elevation in nodulation (40-55 nodules/plant vs. 20 nodules/plant for I-110), and these were evaluated for nodulation competency on soybeans in two field soils under greenhouse conditions. Three clones (VT1, VT2, and VT3) exhibited elevated nodule occupancy (25-75% nodule occupancy compared to 7-20% by the parental I-110). In addition, three clones (VT1, VT2, and VT4) exhibited 50% greater nitrogen fixation activity both *in vitro* and *in planta* compared to parental I-110.

### INTRODUCTION

Biological nitrogen fixation was first shown unequivocally in 1888, yet almost 100 years later, surprisingly little is known about the establishment of the nitrogen fixing symbioses (Hardy & Silver, 1977). Such knowledge is important to basic science as well as applied goals of enhancing nitrogen fixation and broadening the range of biological nitrogen fixation to other valuable crops.

The Gram-negative, aerobic soil bacteria of the root nodule group comprise two taxonomically distinct genera: the fast growing *Rhizobium* species and the slow growing *Bradyrhizobium* species (Jordan, 1982). Members of both genera have the ability to infect leguminous plants and establish a nitrogen fixing symbiosis. The formation of a legume nodule is a complex process involving an array of host and bacterial factors and the interaction of rhizobia and the respective host exhibits a high degree of specificity (Vincent, 1980). This specificity has resulted in the description cross-inoculation groups (e.g., *B. japonicum*-soybean, *R. meliloti*-alfalfa, *R. phaseoli*-bean, *R. leguminosorum*-pea and *R. trifolii*-clover).

Transposon mutagenesis is a powerful method for genetic analysis in bacteria and is therefore particularly appealing for the study of symbiotic properties of *Rhizobium*. While a fairly extensive body of literature has accrued over the past few years from transposon genetic studies of the fast-growing rhizobia, much less information is available for the slow-growing rhizobia such as the soybean microsymbiont *Bradyrhizobium japonicum* (Bridger *et al.*, 1979). The suicide plasmid method of Beringer *et al.*, (1978) has been adopted to isolate kanamycin resistant mutants of *B. japonicum* USDA strain I-110 (Kuykendall and Elkan, 1976) that are enhanced in the symbiotic properties of nodulation and nitrogen fixation.

## MATERIALS AND METHODS

Transposon Tn5 mutagenesis: Introduction of the Tn5 donor "suicide" plasmid PJB4J1 was performed by conjugation with *Escherichia coli* donor strain 1830 (kanamycin (Km<sup>r</sup>), streptomycin (Str<sup>r</sup>), and chloramphenicol (Cm<sup>s</sup>)) to the rhizobial recipients (Km<sup>s</sup>, Str<sup>s</sup>, Cm<sup>r</sup>) using the filter mating technique described by Cen *et al.*, (1982). Two ml each of the recipient culture in mid-log phase and an overnight culture of the donor strain were mixed and filtered onto a 0.45µm filter. The filter was placed on yeast mannitol agar (YMA) for 24hr at 28C after which the cells were resuspended in 5 ml of broth and plated in 100ul aliquots on YMA agar plates containing 500ug Km and 50ug/ml Cm. After 7-10 days Km<sup>r</sup> *Bradyrhizobium* colonies were selected.

Plant screen for symbiotic mutants: Rhizobial cultures were grown on yeast extract broth to an optical density of approximately 1.0 (640 nm). Sterile glass jars filled with sterile vermiculite were used for plant growth. Soybean seeds ('Forrest' cultivar) were surface sterilized in 70% ethanol for 2 min., rinsed three times in sterile distilled water and pregerminated in sterile vermiculite for 48h at 28C. Seedlings were transplanted aseptically into the sterile jar assemblies, inoculated with 1.0 ml of culture, and covered with vermiculite. Plants were maintained for 28 days in a growth chamber at a 14 hour photoperiod with a maximum light intensity of 500 µ Einsteins cm<sup>-1</sup> sec<sup>-1</sup> with a maximum/minimum temperature of 28 / 23C. Typically 100-150 mutants were evaluated in one experiment arranged in four replicate blocks using a randomized block design. Eight non-inoculated controls and eight I-110 parents were included in each planting. Plants were irrigated as needed with filter sterilized deionized water without nutrients.

One thousand Km<sup>r</sup> I-110:Tn5 mutants were screened for altered symbiotic capabilities. Each mutant was used to inoculate three soybean seedlings. After 35 days of growth the symbiotic performance of each mutant was compared to that of the wild-type I-110 parent and non-inoculated controls. The parameters used to determine symbiotic competence were 1) plant color, 2) whole plant acetylene reduction activity, and 3) total number of nodules/plant.

For acetylene reduction assays, single roots were placed in 250 ml Erlenmeyer flasks, filtered with a rubber stopper and a glass tube containing a rubber septum. Acetylene was added to approximately 10% volume and the roots were incubated for 1.0hr at ambient temperature prior to gas sampling. Ethylene concentrations in the incubation chamber were determined on a Perkin Elmer Sigma 2B gas chromatograph fitted with a 1.0m poropak N column and a flame ionization detector. Nitrogen was utilized as the carrier gas at a flow rate of 30 ml/min, with a 50C oven temperature and 150C detector temperature. Following acetylene reduction assays, numbers of nodules per plant were scored. Mutants exhibiting altered nodulation or fixation phenotypes were retested utilizing the above protocol.

Free-living nitrogenase activity screens of symbiotic mutants: Free-living nitrogenase activity of the I-110 parent and mutant strains was determined by the soft agar overlay method of Pankhurst and Craig (1978). After the acetylene reduction assay was completed, the rhizobial cell-impregnated soft agar disc was floated out of the assay vial, digested with 0.3N NaOH at 90C, and whole cell protein determined by the method of Lowry *et al.*, (1951).

Verification of Tn5 insertion by DNA hybridization: In order to demonstrate that the Km<sup>r</sup> I-110 mutants contained a single Tn5 insertion, 32p-labeled Tn5 DNA was used to probe *in situ*, with colonies grown on nitrocellulose filters (Grunstein and Hogness, 1975). The Tn5 containing plasmid PBR322:Tn5 was isolated and purified from *E. coli* DB1706 for use as a hybridization probe. A colony of I-110 and *E. coli* 1830 (PJB4J1) were included on each filter as controls.

Comparison of nodulation rates: A comparison of nodulation over time of Tn-119 and I-110 was conducted. Soybean seeds ('Forrest') were surface sterilized and germinated for 48hr prior to transplanting in modified Leonard jar assemblies (2/pot). Seedlings were inoculated with 0.5 ml of culture (1 x 10<sup>9</sup> cells/ml) and maintained in a growth chamber under the same conditions as described above. The experiment was set up as a randomized complete block of four replicate pots per block per strain. Plants were harvested and nodules counted at 7, 11, 14, 18 and 21 days after planting.

Competition against indigenous rhizobia: Two soils were examined in this procedure. They included a Groseclose silt loam (clayey, mixed, mesic Typic

Table 1. Nodulation of 28 day old 'Forrest' soybean by Bradyrhizobium japonicum I-110 and enhanced nodulation mutants in two experiments (I & II)

I		II	
Strain	No. of Nodules/Plant <sup>x</sup>	Strain	No. of Nodules/Plant
Non-inoculated control	0.0	Non-inoculated control	0.0
I-110 parental	19±6.3 a	I-110 parental	21±5.8 a
1	23±4.4 ab	VT1	45±3.2 b
2	27±5.7 b	VT2	53±5.7 b
3(VT1)Y	45±4.4 d	VT3	46±4.8 b
4	29±4.5 b	VT4	39±4.2 b
5	31±3.4 b	VT5	53±5.1 b
6	24±3.2 ab		
7	30±4.1 b		
8(VT2)	55±5.7 d		
9	31±5.2 b		
10	35±4.6 bc		
11	29±3.0 b		
12	27±4.1 b		
13(VT3)	49±4.6 d		
14	25±5.5 ab		
15(VT4)	42±4.5 d		
16(VT5)	55±3.4 d		
17	33±3.2 b		
18	36±4.1 bc		

<sup>x</sup>Numbers in columns followed by different letters indicate significance at .05 level.

YClones VT1-VT5 selected for evaluation in second experiment.

Hapludult) from Blacksburg, VA, and a Kenansville loamy sand (loamy, siliceous, thermic Arenic Hapludult) from Holland, VA. Both soils contained approximately 10<sup>4</sup> B. japonicum/g. Surface disinfected plastic pots (10 cm diameter 10 cm deep) were filled with a 50/50 v/v mixture of the soil and sterile sand. Four surface sterilized pregerminated (48 hr) 'Forrest' or 'Essex' soybean seeds were planted per pot and 0.5 ml of yeast extract broth culture of the mutants or the parental I-110 were pipetted onto each seed. Plants were thinned to two/plot after emergence. The experiment was designed as a randomized complete block with four replications and non-inoculated controls. Following 35 days of growth, plants were harvested and nodules were typed utilizing yeast extract agar either with or without 500 ug/ml Km to specifically detect the Tn5 containing mutants of strain I-110. Twelve nodules per plant (24 per pot) were typed with this technique. Nodules occupied by parental I-110 were determined by agglutination with specific antiserum prepared against I-110.

Statistical analyses: All experiments were designed as randomized complete blocks with four replications. Significantly different means were determined by the ANOVA procedure and were compared by the SNK multiple range test.

## RESULTS

Of one thousand Tn5 mutants from USDA strain I-110 evaluated by an in-planta screen, 18 mutants (1.8%) were identified that exhibited greater levels of nodulation (15 of 18 were significantly greater at the .05 level, Table 1). A second evaluation with the five mutants that produced the highest numbers of nodules confirmed the enhanced nodulation trait (Table 1). Mutants were recovered that demonstrated reduced nodulation (lower than parental I-110) at an equivalent frequency to that observed for enhanced nodulation. Only mutants with improved phenotypes were considered for further



Table 2. Symbiotic properties of USDA Bradyrhizobium japonicum strain I-110 and five mutants on 'Forrest' cultivar.

Strain Designation	Nodule Number	ARA/Plant <sup>x</sup>	ARA/Free-Living
I-110Y	19.6a	2.6a	42.6a
VT1	47.9b	3.8b	62.3b
VT2	54.6b	3.7b	58.4b
VT3	47.1b	2.8a	44.9a
VT4	40.4b	3.4b	63.7b
VT5	54.7b	3.0ab	43.1a

<sup>x</sup> ARA = Acetylene Reduction Activity, 2 replications, nMoles C<sub>2</sub>H<sub>2</sub> per hour per mg protein.

y Numbers in columns followed by different letters indicate significance at the .05 level.

Table 3. Rate of nodulation of USDA Bradyrhizobium japonicum strain I-110 and five mutants on 'Forrest' soybean cultivar.

Strain	Harvest (days after planting)				
	7	11	15	19	23
I-110	1.6a <sup>x</sup>	8.4a	13.6a	19.4a	26.3a
VT1	2.2a <sup>y</sup>	7.3a	12.6a	27.1b	39.1b
VT2	1.9a	8.1a	13.7a	18.2a	35.6b
VT3	6.5b	20.2b	27.8b	31.0b	43.4b
VT4	4.7b	16.9b	22.4b	29.3b	38.9b
VT5	2.0a	8.9a	15.6a	21.2a	40.3b

<sup>x</sup> Number of nodules per plant at the respective harvest day.

y Numbers in columns followed by different letters indicate significance at the .05 levels.

Table 4. Nodule occupancy by I-110 and five transposon derived mutants of Bradyrhizobium japonicum on soybean cultivars grown in two Virginia soils.

Strain	Percent nodule occupancy <sup>x</sup>			
	<u>Blacksburg Soil</u>		<u>Holland Soil</u>	
	Forrest	Essex	Forrest	Essex
I-110	17a	20a	7a	11a
VT1	63b	75b	42b	53b
VT2	41b	52b	25b	36b
VT3	52b	61b	17a	41b
VT4	14a	19a	9a	14a
VT5	24a	31a	14a	19a

<sup>x</sup> Numbers in columns followed by different letters indicate significance at the .05 level.

evaluation. A third in-planta evaluation of these five mutants demonstrated that, in addition to elevated nodulation, three of the mutants (VT1, VT2, and VT4) exhibited superior nitrogen fixation rates both in-vivo and in-planta based on the acetylene reduction assay (Table 2). The other two mutants (VT3 and VT5) did not differ significantly from the parental I-110 in nitrogen fixation rates although both retained the elevated nodulation phenotype.

Two mutants (VT3 and VT4) demonstrated the ability for rapid nodulation (Table 3). This characteristic was detectable at the seven day harvest for both mutants and continued through the nineteen day harvest. By the fifth

Table 5. Summary of plant phenotype expression associated with five mutants of *Bradyrhizobium japonicum* USDA strain I-110.

Strain	Nodulation		Nitrogen fixation		Competition in soil
	No. of nodules	Earliness	In-vivo	In-planta	
I-110	--- <sup>x</sup>	---	---	---	---
VT1	+	---	+	+	+
VT2	+	---	+	+	+
VT3	+	+	---	---	+
VT4	+	+	+	+	---
VT5	+	---	---	---	---

<sup>x</sup> Indicates whether each characteristic was (+) or was not (---) present in the parent strain and mutants.

harvest (23 days) the earliness of nodulation phenotype was no longer apparent and all five mutants were equivalent although each produced higher nodule counts than the parental I-110. Greater numbers of nodules were detectable on mutant VT1 at the 19 day harvest.

In two Virginia soils, mutants VT1, VT2, and VT3 were more competitive (in nodule occupancy) against indigenous strains than the parental I-110 (Table 4). Mutants VT4 and VT5 were not significantly different in either soil from the parent strain. There was no significant cultivar effect ( $t = .10$ ) although the proportion of occupied nodules appeared to be higher on 'Essex'. There was a significant soil effect ( $t = .10$ ) in that nodule occupancy was reduced on plants grown in the Holland soil. Mutant VT3 was not superior to the parental I-110 on 'Forrest' in the Holland soil but did occupy higher numbers of nodules in all other treatments (Table 4). The Holland soil was from a field that had a history of soybean production and, even though the indigenous population was no larger than that from the Blacksburg soil, the indigenous strains appeared to be highly competitive.

#### DISCUSSION

The frequency of kanamycin resistant ( $km^r$ ) exconjugants after crossing with *E. coli* 1830 was in agreement with results from other reports (Meade *et al.*, 1982) and resistance occurred approximately one hundred times more frequent than the rate of spontaneously occurring  $km^r$  colonies (data not shown). The mutant phenotypes were highly correlated with  $km^r$  and hybridization of Tn5 DNA, both *in situ* and by the technique of Southern (1975), indicated the  $km^r$  I-110 exconjugants were the result of Tn5 insertions into the genome of I-110. The Tn5 inserts appeared to be stable in I-110, because the  $km^r$  trait of the mutants survived several hundred generations of growth in a medium containing no kanamycin. Mutants VT1 thru VT5 retained the  $km^r$  trait after reisolation from soybean nodules.

The plasmid PJB4J1 proved to be a reliable suicide plasmid suitable for Tn5 mutagenesis of *Bradyrhizobium*. A high percentage of the  $km^r$  mutants were sensitive to the PJB4J1 markers (streptomycin and spectinomycin) suggesting that PJB4J1 did behave as a suicide plasmid.

No single mutant strain demonstrated enhanced activities in every symbiotic characteristic that was evaluated (Table 5). One mutant (VT5) was chosen initially because it produced elevated numbers of nodules on plant roots, however, this proved to be its only distinguishing characteristic (Table 5). In contrast, mutants VT1, VT2, and VT4 were enhanced in all but one of the evaluated symbiotic characteristics. Mutant VT4 was enhanced in all examined characteristics except the ability to compete in soil in the presence of an indigenous *Bradyrhizobium* population (Tables 4 & 5). Competitiveness in soil is an essential feature if an amended strain is to be successful in obtaining nodule occupancy sites (Vincent, 1980) and lack of this characteristic may limit the practical utility of VT4. Mutants VT1 and VT2 appeared identical in almost every feature, including an inability to cause early nodulation (Tables 3 & 5). This may not be a restrictive feature since the importance of early nodulation has yet to be proven (Russell *et al.*, 1985).

Mutants VT1-VT4 demonstrate that single deletion events can cause multiple phenotypic changes. Some common regulator or promotor region appears to control the genetic function of several characteristics associated with symbiotic nitrogen fixation. This observation has been reported previously (Halverson & Stacey, 1986) although the mechanisms involved are not yet understood. Future research to determine the location of the Tn5 insertions should examine the function of the genes associated with the multiple phenotypic changes. A comparison of the location of the Tn5 marker between the five VT mutants may provide some information regarding the way that Bradyrhizobium regulates several of the mechanisms involved in the legume symbiosis.

Additional experimentation should examine the mutants on a wider range of soybean cultivars and soils. It would be valuable to examine mutants VT1 and VT2 under the most realistic conditions of a field trial, but greenhouse studies should first be undertaken to further determine the competitiveness of the mutants. Other data that are needed on these mutants include survival in soil, the rates of nodulation and nitrogen fixation on plants in natural soils. It is through the development of symbiosis enhanced Bradyrhizobium strains that a potential exists for increasing nitrogen fixation and yields of legume crops.

## LITERATURE CITED

- Beringer, J. E., J. L. Beynon, A. V. Buchanan - Wollaston, and A. W. B. Johnston. 1978. Transfer of the drug-resistance transposon Tn5 to Rhizobium. *Nature*, 276:633-634.
- Bridger, G. W., R. F. Gadsby, and D. E. Ridler. 1979. p. 291. In: Hardy, R. W. D., F. Bottomley, and R. C. Burns (ed). A treatise on Dinitrogen Fixation, Vol. 1. John Wiley and Sons, New York.
- Cen, Y., G. L. Bender, M. G. Trinich, N. A. Morrison, K. F. Scott, P. M. Gresshoff, J. Shine, and B. G. Rolfe. 1982. Transposon mutagenesis in rhizobia which can nodulate both legumes and the nonlegume Parasponia. *Applied Environ. Microbiol.* 43:233-236.
- Grunstein, M. and D. Hogness. 1975. Colony hybridization: A method for the isolation of cloned DNA's that contain a specific gene. *Proc. Nat'l. Acad. Sci.* 72:3961.
- Hardy, R. W. F., and W. S. Silver (ed). 1977). A treatise on dinitrogen fixation, Vol. III. John Wiley & Sons, New York.
- Halverson, L. J., and G. Stacy. 1986. Signal exchange in plant-microbe interactions. *Microbiol. Rev.* 50(2):193-225.
- Jordon, D. C. 1982. Transfer of Rhizobium japonicum to Bradyrhizobium. A slow-growing root nodule bacterium from leguminous plants. *Int. J. Syst. Bacteriol.* 32:136-139.
- Kuykendall, L. D. and G. H. Elkan. 1976. Rhizobium japonicum derivatives differing in nitrogen-fixing efficiency and carbohydrates utilization. *Applied Environ. Microbiol.* 36:915-919.
- Lowry, O. H., N. J. Rosenbrough, A. L. Farr, and R. G. Randall. 1951. Protein measurement with the folin phenol reagent. *J. Biol. Chem.* 193:265-275.
- Meade, H. M., S. R. Long, G. B. Ruvkun, S. E. Brown, and F. M. Ausubel. 1982. Physical and genetic characterization of symbiotic and auxotrophic mutants of Rhizobium meliloti induced by transposon Tn5 mutagenesis. *J. Bacteriol.*, 149(1):114-122.
- Pankhurst, C. E. and A. S. Craig. 1978. Effect of oxygen concentration, temperature and combined nitrogen on the morphology and nitrogenase activity of Rhizobium Sp. Strain 32H1 in agar culture. *J. Gen. Microbiol.* 106:207-219.
- Russell, P., M. G. Scheil, K. K. Nelson, L. J. Halverson, K. M. Sirotkin, and G. Stacy. 1985. Isolation and characterization of the DNA region encoding nodulation functions in Bradyrhizobium japonicum. *J. Bacteriol.* 164(3):1301-1308.
- Southern, E. 1975. Detection of specific sequences among DNA fragments separated by gel electrophoresis. *J. Mol. Biol.* 98:503-517.
- Vincent, J. M. 1980. Factors controlling the legume-Rhizobium symbiosis, p. 103-130. In W. E. Newton and W. H. Orne-Johnson (ed.), *Nitrogen Fixation*, Vol. 1. University Park Press, Baltimore.



## A Preliminary Survey of Computer Use by College Freshman Level Biology Students

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Much emphasis has been given to developing computer based instruction for biological education, especially in high school level classes (Duncan and Harris, 1985). Collegiate texts are accompanied by ancillary materials which include computer software. The assumption is that use of computers contributes to the success of students in biology classes.

We were interested in determining if computer materials were being used by students in freshman level biology classes. Virginia Polytechnic Institute and State University has an enrollment of over 20,000 undergraduate and graduate students. The enrollment in freshman level biology exceeds 1000 students. Specifically, we were interested in the following:

1. Do biology students as a whole use computers for biology class/lab as often as for other classes?

2. If students use computers for class/lab work, what applications do they use?

3. If students use computers, are there any differences between use by majors and non-majors?

Six sections of freshman level biology laboratory were selected. Three sections were Principles of Biology sections designed for students majoring in biological sciences. The other three sections were General Biology for students majoring in other fields. There were 65 students in each survey group. There were 34 males and 31 females in the majors group and 25 males and 40 females in the non-majors group. In both groups, more than 70% reported grades of B or better for biology lab for the previous quarter, less than 20% owned their own computers, and over 40% said they could write computer programs.

The survey was administered during the last two weeks of classes of spring quarter, 1987. Completed surveys were hand scored and statistical analysis followed methods described by Wood (1977). A partial summary of the statements in the survey is provided (Table 1).

Table 1. Statements for which responses were true or false.

- 
- |     |   |
|-----|---|
| 1.  | In high school I took biology.                        |
| 2.  | In high school I took chemistry.                      |
| 3.  | In high school I took physics.                        |
| 4.  | In high school I took advanced biology or biology II. |
| 5.  | In high school I took a computer science course.      |
| 6.  | I use a word processor program.                       |
| 7.  | I use a spreadsheet program.                          |
| 8.  | I use a data base program.                            |
| 9.  | I used a computer in biology class/lab.               |
| 10. | I used a computer for class work other than biology.  |
-

Results for questions 1-10 are presented in Table 2. Questions 1-8 were analyzed for differences between the two groups: majors and non-majors. Statements 9 and 10 were combined for all students. Two students did not respond to statement 10.

Chi squared values were used for comparisons of the differences between the majors group and the non-majors group. There were no significant differences in the backgrounds of the students except for those who took chemistry ( $p < 0.01$ ) or advanced biology ( $p < 0.001$ ). There was a significant difference ( $p < 0.0001$ ) in the use of computers in and out of biology classes.

Although there are many good software packages available in biology which simulate, tutor, test and help analyze data, they were apparently not used by the students in this study group. A significantly larger number of students used computers in other classes. If computers contribute to the success of students in biology, this contribution was not seen in these groups.

Most of the students who used computers used word processor programs. Very few in either group utilized spreadsheets or data bases. Between the majors and non-majors, there were no overall differences in computer use.

These results raise several questions which pertain not only to the students, but to their instructors as well. Are students aware of the numerous software packages available to them? Are they aware of the school-supported computer facilities at their disposal? Are educators arranging the course material so as to promote computer use, e.g., statistical analysis, data summation, etc.? Are faculty members in general encouraging the development of computer skills? Lastly, are computer courses designed to help students realize the variety of applications they could make to their other courses? While these results are only preliminary, they do indicate a need in science education for additional emphasis on computer applications to scientific studies.

Table 2. Summary of results of the survey of majors and non-majors in biology.

Statement	Percent Majors Responding True	Percent Non-majors Responding True
1.	96.9	96.9
2.	100.0	90.8
3.	80.0	69.2
4.	50.8	20.0
5.	55.4	64.6
6.	52.3	38.5
7.	9.2	16.9
8.	15.4	9.2
9.	23.1	3.1
10.	67.7	63.1

#### Literature Cited

- Duncan, K. and D. Harris (eds.). 1985. Computers in Education. 1038 pages. Elsevier Science Publishers, North-Holland.
- Wood, G. 1977. Fundamentals of Psychological Research. 372 pages. Little, Brown, and Co., Boston.

**Virginia Academy of Science Council Meeting**  
**November 8, 1987**  
**University of Virginia (Ruffner Hall)**

President W. L. Banks called the meeting to order at 1 P.M. Others present were D. Ulrich, R. N. Giese, R. Brandt, G. I. Holtzman, S. Ware, C. Blair, V. B. Remsburg, W. R. West, Jr., C. R. Taylor, R. D. Decker, A. D. Campbell, E. Thompson, A. F. Conway, S. Colucci, J. P. O'Brien, T. O. Sitz, H. M. Bell, G. Sanzone, J. J. Murray, and M. L. Bass. President Banks asked each to introduce themselves to the Council. M. Bass kindly accepted the responsibilities of recording secretary in the absence of P. Homsher.

The minutes of the May 20 and May 22, 1987 meetings were approved as distributed. President Banks distributed a preliminary copy of the Directory and asked all to make appropriate changes.

President Banks introduced the report from the Executive Committee. The first item was an invitation from Virginia Commonwealth University to host the 1989 annual meeting. J. J. Murray moved that the invitation be accepted and this motion was seconded by V. B. Remsburg. After discussion of the invitation, the motion was unanimously approved.

President Banks announced that we have continued our affiliation with AAAS. He also brought up a recommendation from the Executive Committee that an ad hoc committee be appointed to examine the organization and administration of the VJAS with respect to its relationship to the senior Academy and the increased responsibilities of the VJAS Director. J. P. O'Brien moved that the ad hoc committee be appointed by the President, and this motion was seconded by G. Sanzone. After discussion, the motion was passed unanimously. A preliminary report will be due at the March Council meeting.

B. Bruner reported that membership is not increasing but is staying about the same.

S. Colucci reported on the activities of the Local Arrangements Committee (LAC) for the May 1988 meeting. The LAC membership has been finalized and is composed of about 20 members. He distributed maps of the University of Virginia campus and reviewed in which buildings the Academy meetings would be held. Thirty-five rooms for VJAS and 20 for VAS have been requested for the Academy meetings and dormitory and cafeteria spaces have been designated for the VJAS students. Senior Academy members can stay there also. The Cavalier Inn will be the headquarters hotel for the meetings. Howard Johnson's will also have rooms reserved for the meetings. The VAS banquet will be in the Rotunda and the talk after the banquet will be in Newcomb Hall. The VJAS Picnic will be in the Dell, behind and to the side of Ruffner Hall.

S. Colucci suggested that the \$15 registration fee should be adequate for this year's meeting. He stated that the final housing fees had not been established because the housekeeping force must be paid overtime since the meetings are being held at a time between the end of the academic year and the beginning of summer programs. The registration fee also includes limited risk insurance for the participants. B. Bruner reported that after expenses were deducted from the 1987 meeting at Old Dominion University, the net profit for the meeting



was ca. \$5000. However, President Banks reiterated that the intent of the meeting is not to make a profit but to break even.

S. Colucci reviewed the parking areas to be used for the meetings and indicated parking fees would be incorporated into the registration fee. Permits will be issued to vendors and registrants. The costs of shuttle buses for elderly attendees and how these should be paid was discussed, but no decision was reached.

C. Blair addressed money for expenses incurred in preparation of the meeting. It was suggested a small amount be available for the LAC but money from exhibitors is received early and can support the initial expenses well.

S. Colucci stated he is in the process of appointing the LAC subcommittees and assigning their duties. President Banks asked S. Colucci for copies of the LAC committee and subcommittee memberships.

President Banks announced that he was unable to get Surgeon General Koop to be the Negus Lecturer. He will continue to look for potential speakers and will contact S. Colucci when one is identified.

S. Ware distributed the time table for the May meeting. Corrections were discussed.

C. R. Taylor, Co-Chairman of the Fund Raising Committee reported on the attempt to bring further state funds into the VJAS budget. The VJAS Budget is not keeping up with the costs. A direct payment of \$39,767/biennium was requested but this request was turned down. President Banks recommended a lobbying effort with our representatives to make the case that science today is different and should have legislative support. R. D. Decker stressed the impact of the number of people and students who are involved with VAS/VJAS programs. V. Remsburg suggested that we direct some effort toward getting some of the lottery money applied to this problem. President Banks reminded Council that this was a preliminary report to provide information about the problem. J. P. O'Brien indicated that we should become more active now if we are to make an impact on the next legislative session but President Banks stated he felt it was too late to have it considered then.

T. Sitz reported for the Research Committee. After reviewing the current review dates and limits of awards for both the Horsley Cancer Grants and the Small Research Awards, he recommended that the Research Committee review grants once each year (in the Spring) instead of twice and that the maximum Small Grants Award be increased from \$500 to \$1000. In connection with the latter recommendation, T. Sitz also recommended that the Research Grants budget be increased from \$5000 to \$6,000. President Banks split the report into three parts for discussion and voting: The single review days, the increase in the maximum award from \$500 to \$1000, and the increase in the total budget to \$6,000.

- a. J. J. Murray moved that the Research Committee be allowed to review grants once each year. This motion was seconded by R. Brandt. After discussion, this motion was approved unanimously.
- b. R. D. Decker moved that the maximum Small Research Award be increased to \$1,000 per grant. R. Brandt seconded this motion. After discussion, this motion was approved unanimously.
- c. The issue of listing the graduate student's advisor as a coinvestigator was split off for separate consideration. T. Sitz moved and J. J. Murray seconded the motion that in the case of a graduate student applying for grant funding, the student's major advisor be listed as a coinvestigator and

that this be stated in the guidelines. This motion passed but with dissent.

- d. Before moving to the third part of the Research Committee request (i.e., the increase of the amount of money for small grants awards), the President asked D. Ulrich to give the Trust Committee report. The report was distributed and the discussion centered around the amount of money being generated by the Trust for Research. This was estimated to be \$4500 for the year 1988-89 to avoid using any of the principal. A lengthy discussion about how Trust Funds and General Operating Funds can be used followed. C. Blair moved that for the coming year the amount applicable to research be the amount recommended by the Trust Committee (i.e. \$4500) and that, between now and the annual meeting, a policy on how the usable research funds are to be identified be established by the Trust Committee for presentation to the Council meeting in May. This motion was seconded by G. Sanzone and passed unanimously.

D. Ulrich stated that the Research Fund was moved from a savings account to the investment portfolio listed on April 30, 1984, and the initial investment was \$56,000. In spite of the recent losses, this account now has \$80,000+ and so it has grown. Possibly some of the \$80,000 can be considered other than corpus and would be usable.

A. Burke presented the Finance and Endowment Committee report. There were no significant changes in the proposed budget compared to last year's figure. A. Burke moved acceptance of the budget as distributed and this motion was seconded by A. D. Campbell. The motion was approved unanimously.

At this point, President Banks had to leave the meeting (3:15 P.M.) as he had announced previously, and Immediate Past President J. J. Murray became Chair. Prior to leaving the meeting, President Banks noted that the March Executive Committee and Council meetings will be held March 12 in Ruffner Hall of the University of Virginia, the Executive Committee convening at 10 A.M. and the Council meeting convening at 1 P.M. He requested that all Committee Chairs provide him with copies of their reports at least two weeks prior to that meeting.

The Council meeting reconvened at 3:20 P.M. with J. J. Murray presiding. He called for Old Business.

The first order of Old Business was introduced by J. J. Murray; the establishment of a Fellows Fund. This money will be used to support activities not normally provided for in the annual budget. He distributed a description of the fund and how it will be managed and operated. The Fellows Fund will be administered by three Fellows, one leaving and a new one elected each year. Any projects for this fund are to be submitted to the Executive Secretary-Treasurer who will pass these on to the Chair of the Fellows Fund for consideration by all the Fellows. R. D. Decker moved acceptance of this plan and this motion was seconded by E. Thompson. An amendment to strike the portion of the proposal dealing with making the recommendations at the Fellows Breakfast and leaving it to the Fellows when they will decide which proposals are to be funded was offered by J. D. O'Brien. This was seconded by S. Ware and approved unanimously. The original motion was then passed unanimously. There was no further Old Business.

J. J. Murray reintroduced consideration of the Trust Committee report and D. Ulrich reviewed the portion not previously considered. The Fellows Fund is to be reported as part of the General Operating Fund but the usable income should be reported separately. Extensive discussion about this report ensued and the Trust Committee was asked to report usable income rather than total fund amounts in future reports.

The Council also asked the Trust Committee to discuss what can be done with respect to the Bethel High School fund awards account. Both the Bethel High School award and the Botany award are giving more money than they are generating and this problem must be addressed.

J. J. Murray then introduced the Visiting Scientist Program Report for discussion and asked H. M. Bell to present the report. He distributed the report and drew the council's attention to paragraph 3. This stated that the Roanoke Post Office has been secured as an additional entry station for VAS non-profit mailing. The advantages of this are that this makes it no longer necessary to transport this large mailing to Richmond to be processed and the service is cheaper than Richmond.

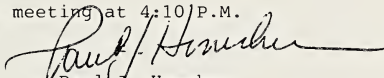
W. West reported that the Awards Committee has several nominations for Fellows but they can not act on these because of the fact that, unless the Academy membership increases or a vacancy occurs in the Fellows membership, no new Fellows can be added. This dilemma is currently before the Constitution and By Laws Committee and should be reported out of committee at the March Council meeting.

J. J. Murray called for other New Business. The location of the 1990 meeting was raised and J. J. Murray asked people to discuss the possibility of hosting VAS/VJAS with officials at plausible institutions. If there is interest, he asked that contact with President Banks be made.

C. Blair stated that several people in the Department of Computer Science at Old Dominion University would have an interest in establishing a Computer Science Section of the Academy. All were asked to bring this up to the computer scientists at their institutions and, if interested, contact Dr. James Schwing, Department of Computer Science, Old Dominion University, Norfolk, VA 23529. The VJAS already has a separate Computer Science Section.

J. P. O'Brien brought up the fact that July 1988 is the bicentennial of Virginia's ratification of the U.S. Constitution. The Virginia Bicentennial Commission is developing a miniseries for PBS about this and he would like discussion of what we might do so that the Academy's name might be associated with the celebrations surrounding this event.

J. J. Murray adjourned the meeting at 4:10 P.M.



Paul J. Homsher  
Secretary, VAS



**Virginia Academy of Science Committee Meeting  
November 8, 1987  
University of Virginia (Ruffner Hall)**

The meeting was called to order at 10:05 A.M. by President W. L. Banks. Others present were B. Bruner, R. D. Decker, J. J. Murray, E. Thompson, S. Ware and G. Holtzman. P. Homsher was absent but M. Bass kindly agreed to sit in for him and assume the duties of recording secretary.

President Banks opened the meeting by reviewing his agenda for the afternoon meeting of the VAS Council. He asked President-elect Ware for his report on the May meeting arrangements. One thing that was added was for Section secretaries to remain after the meeting and identify one male and one female student presenter (from the nominations received from all sections) who will receive the AAAS membership awards. The names and addresses of these students are to be sent to the Director of the VJAS. It was also noticed that the annual meeting dates were wrong on the schedules distributed. The correct dates are May 24-27, 1988.

J. J. Murray requested that the Local Arrangements Committee (LAC) membership be identified as soon as possible. R. D. Decker agreed to help S. Ware with the duties LAC will perform. It was also emphasized by R. D. Decker that E. Thompson must be the VJAS representative on LAC.

President Banks reported that Surgeon General Koop can not be our general seminar speaker. Several others were discussed, among them Bob Dolon, President of CIT and Betsy Dresser, an embryologist from the University of Cincinnati. However, there is no firm commitment from anyone.

S. Ware suggested that an attempt be made to have the speaker speak in the same room as that in which the banquet is held rather than move to a separate location. However, no one knew if facilities were available at the University of Virginia to accommodate both in the same room and discussion centered on whether it was best to have the speaker in the same room as the banquet, forcing everyone to go to both, or have the speaker in another room after the banquet so anyone not at the banquet could hear the speaker without suffering the cost of the banquet.

President Banks distributed copies of the Directory but indicated the first page was missing. This will be added later.

President Banks read a letter from Virginia Commonwealth University offering to host the VAS/VJAS meeting in 1989. After discussion about comments from R. D. Decker that some teachers felt there were security, environmental, and parking problems at VCU, the Executive Committee voted to recommend holding the meeting there from May 23 to May 26, 1989. President Banks agreed to look into the possible problem areas. This recommendation will be made to the Council in the afternoon. R. D. Decker stated that the University of Richmond would be available as an option if no other invitation is available and the VCU offer is rejected by Council. A general discussion of academic institutions around the state which could accommodate VAS/VJAS ensued.

President Banks asked R. D. Decker to discuss the status of the VJAS State Budget request. Meetings with certain state officials were discouraging. They stated that they did not think that state funds could be appropriated for this type of use. The next step will be a lobbying action. The request is for \$39,769 biennially. The request was to fund student research grants, printing costs for the proceedings and handbook, and secretarial help. C. Roy Taylor and J. Uwaydah will make the presentation at the afternoon Council meeting.

R. D. Decker indicated that he would like to consider retirement from the VJAS Directorship. However, he felt that the amount of work involved warranted consideration as a possible paid, full-time position, similar to the Executive Secretary-Treasurer job. President Banks said he would consider appointing an ad hoc committee to study the situation with the intention of having a preliminary report back by the March meeting. B. Bruner pointed out that if the position is approved, the budget and physical location of this person is a problem since the University of Richmond is kindly giving the Academy space now but it is not adequate to house another full-time employee and his/her records. President Banks suggested R. D. Decker, E. Thompson, A. Burke and J. J. Murray, Jr. as possible members of this committee. Others suggested were Mary Frances Hobbs, Julia Kaufman, B. Bruner and D. Cottingham. The concept will be brought before the Council in the afternoon.


President Banks referred to a note from V. Remsburg concerning the Virginia Museum of Natural History and mentioned that no action has been taken on this. None was taken at this meeting but it will be brought before the Council this afternoon.

President Banks read a proposal from T. Sitz, Research Committee Chairman. The proposal suggested that Small Projects Grants be reviewed once each year (Spring) rather than twice, that the maximum award be \$1000 and that a graduate student be allowed to apply only if his/her major advisor is a co-investigator on the grant. The proposal also asked that the total amount to be spent on grants be raised to \$6,000, plus the \$500 Horsley Award. If this is approved and the additional money is to come from the General Fund, it would become a budget item and would require reallocation from some other part of the operational funding base. If there are surplus funds, these could be used to support the increase. B. Bruner noted that if the requested increase is to be implemented for the next fiscal year, the Council would need to recommend it at the afternoon meeting since there is no other Council meeting between now and the next fiscal year. J. J. Murray recommended against putting general funds into the research category without further study. He recommended that the recommendation should be divided into its separate parts and presented to Council.

President Banks made a membership report. B. Bruner stated that we are essentially on par with last year. President Banks asked each member of the Executive Committee to bring in one new member.

J. J. Murray brought up the organization of the Fellows Fund to be presented to Council at the afternoon meeting. He distributed a description of this and reviewed it. It was put under Old Business for the afternoon Council meeting.

The meeting adjourned at 11:50 A.M.

  
Paul J. Homsher  
Secretary, VAS

**Virginia Academy Executive Committee Meeting  
January 30, 1988  
University of Virginia (Ruffner Hall)**

The meeting was called to order by President W. L. Banks at 10:03 A.M. Others present were E. Thompson, S. Ware, G. Holtzman, R. D. Decker, S. Colucci, T. Tyler, B. Bruner, J. J. Murray and P. J. Homsher.

President Banks began by reviewing the program for the May meeting. All materials are to be received by March 11 to be reviewed at the March 12 meetings (Executive and Council). The VJAS assignments go to S. Ware. Each will fine tune the match-up of rooms and sections by looking at the number of papers to be offered and room size (and any historical information on attendance that could help).

S. Colucci, Chair of the Local Arrangements Committee (LAC) reviewed the plans for the meeting in detail. He provided each with a map of the University of Virginia campus and a copy of the calendar of events and went over each part of the plan in detail chronologically, starting with the arrival of R. D. Decker. The highlights of the presentation were as follows:

On Tuesday

- a. R. D. Decker arrives about noon Tuesday as do most of the exhibitors. Need handtrucks and labor available. Each exhibitor needs a 3'x 8' table.
- b. The VAS needs about five handicapped parking spaces.
- c. VJAS buses will park in the West Lot of Scott Stadium.
- d. It would be desirable to provide several keys to the rooms assigned to VJAS for R. D. Decker and his associates.
- e. Optimally all VJAS meetings and rooms should be in the Chemistry building.
- f. The VJAS paper room could be a chemistrsy laboratory with many table tops.
- g. There will be a shuttle from the hotels to the meeting.
- h. Chemistry Building will need a night guard so that exhibits can remain up overnight.
- i. Upon arrival of each bus, teacher(s) disembark(s) and go(es) into the lobby of Chemistry Building to get the registration packets for the students and others on their bus. The teacher(s) will also pick up the students' keys and housing information at the Chemistry Building. The bus waits for the teacher(s) who reboard(s) the bus and progress(es) to the dorms. Once the buses are parked, they will probably not need to be moved until departure day.
- j. Middle school students need to be housed away from the junior and senior students.



- k. Registration will extend from 3 to 8 P.M. on Tuesday.
- l. A contingency plan for handling late arrivals will be worked out and sent to the schools in the information sent to schools prior to arrival.
- m. Housing assignments will be made by S. Colucci.
- n. On Tuesday, the students and the committee will eat in the Newcomb Hall. The Committee will eat in the Commonwealth Room of Newcomb Hall.
- o. Practice space for the students to work on their talks will be available in the dorm suites and lobby Tuesday night.

On Wednesday

- a. Judges need donuts, coffee and juice, and a place to meet. The judges will meet in the Chemistry Building lecture hall. Food should be inside the hall so the public does not take the food.
- b. The Committee needs donuts, coffee and juice, and a room. This could be the small lecture room near the auditorium.
- c. The exhibitors may provide coffee for all in the Chemistry Building lobby.
- d. Lunches will be staggered at 11:30, 12:00 and 12:30; one-third of each of the students going at each of those times.
- e. The paper sessions for VJAS will be in buildings 38, 39, 41, 42, 64, 65, 92, 93, 95 and 98 on the map provided by S. Colucci.
- f. Three small rooms, close together, are needed for the Science Talent Search interview. These will probably be in Ruffner Hall.
- g. The judges' lunch will be catered and in either the Commonwealth Room (Newcomb Hall) or the end of the ballroom. These will be staggered also at 11:30, 12:00 and 12:30.
- h. The Business Community Reception site will be arranged.
- i. The VJAS Picnic will be in the Amphitheater with a rain site at Newcomb Hall.
- j. Award Paper's Committees will probably meet in presentation rooms.
- k. Be sure section meeting rooms are open and set up with visual equipment at 8 A.M. It is desirable to have a projectionist in each room.
- l. The VJAS dance will be in the Ballroom with entertainment yet to be arranged. Snacks will be catered. It would be good to have security at the dance.
- m. The VJAS Speaker has not been finalized but Rae Carpenter and Dick Minnix have been invited to do a demonstration.
- n. The Education Section of the Seniors has a meeting on Wednesday afternoon and E. Thompson will reserve a room in Ruffner Hall for this.
- o. Council and Executive Committee meetings are scheduled for rooms in Ruffner Hall.
- p. Wednesday P.M. is the beginning of the VAS registration. Packets

should include a restaurant guide and map of the area and campus, if possible, with their registration materials.

- q. Must have membership forms at the registration table for non-members and must be prepared to receive dues from some.

On Thursday


- a. VJAS Awards Program will be in the Chemistry Building Auditorium. An anteroom adjacent to this is needed for photography and should have a small table and outlets for lights. The stage of the auditorium should have a microphone, table and some chairs. It begins at 8:30 A.M.
- b. The winners of the VJAS sections must be scheduled into the VAS sessions.
- c. The Fellows breakfast will be at the Cavalier Inn. Personal cars will be used to shuttle fellows back to campus. J. J. Murray and E. Thompson will arrange this.
- d. The Academy Conference will be in the Chemistry Building Auditorium.
- e. Section meetings for VAS will be in buildings 38, 39, 41, 42, 92, 93 and 95 on the map distributed by S. Colucci. They will be set up by 7:30 A.M. and be open up to 6:00 P.M. or after.
- f. Lunch will be at the discretion of each but Newcomb Hall cafeteria will be available at which you can buy food.
- g. Two rooms are needed after the paper sessions (rooms previously used as section meeting rooms are fine) for brief committee meetings.
- h. The reception will be at the Colonnade Club.
- i. The banquet will be in the Rotunda (limited to 104). Cost will be between \$15 and \$22. A head table is needed. A University official is needed to welcome the Academy. The Horsley Award should be presented at the banquet.
- j. The lecture will be in South Meeting Room of Newcomb Hall.

On Friday

- a. VAS Council Breakfast will be from 7-8 A.M. at the Cavalier Inn.
- b. Registration is scheduled from 8-10 a.m.
- c. Most exhibitors will leave Friday A.M. or Thursday P.M.
- d. The rooms in Ruffner Hall used for the Science Talent Search can be used for Committee meeting rooms.
- e. VAS Council meeting is at 9 A.M. in Ruffner Hall 187.

President Banks noted that the March 12 Council meeting will begin at 1 P.M. and the Executive Committee at 10 A.M.

The meeting adjourned at 1:18 P.M.

  
Paul J. Homsher  
Secretary, VAS

## **\*Constitution of the Virginia Academy of Science**

### **ARTICLE I: NAME**

The name of this organization shall be the Virginia Academy of Science.

### **ARTICLE II: PURPOSE**

The purpose of this organization shall be to establish and maintain in Virginia for scientific and educational purposes an association of persons and organizations interested in science and scientific research in all of its branches; to solicit financial and other support; to cooperate with educational institutions, industries, and state agencies in fostering an interest in scientific matters, in promoting scientific investigations and in spreading knowledge of the sciences; to provide a forum for the presentation and discussion of papers on scientific subjects and facilities for their publication; to provide opportunities for the cooperation and fellowship among its members; and generally, in doing these things, to benefit not only its own members, but to promote the civic, agricultural, academic, industrial and commercial welfare of the people of Virginia.

### **ARTICLE III: ORGANIZATION**

#### **Section 1. Membership**

Membership in this organization shall be open to professional scientists of all branches of science and others who are interested in the purpose of the organization. Types of membership and dues for each shall be specified in Academy Bylaws. The membership, through the Academy Conference, provided by Section 2 of Article VIII, shall have ultimate authority over the affairs of this organization.

#### **Section 2. Sections**

The Academy shall be organized into sections according to the various scientific disciplines. A person may belong to one or more sections in accordance with his interests.

#### **Section 3. Council**

The governing body of this organization shall be the Academy Council. Its composition and responsibilities are specified in Article VII.

#### **Section 4. Officers**

The elected officers of this organization shall be a President, a President-elect, a Secretary, and a Treasurer. Duties of each shall be specified in Academy Bylaws.

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#### **Section 5. Executive Committee**

The elected officers, the immediate past president and the Director of the Junior Academy of Science shall comprise the Executive Committee of the Academy Council.



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## Section 6. Standing Committees

The primary activities of this organization shall be implemented by Standing Committees as follows: The Research Committee, the Long Range Planning Committee, the Junior Academy of Science Committee, The Membership Committee, the Finance and Endowment Committee, the Trust Committee, the Publications Committee, the Awards Committee, the Fund Raising Committee, the Nominations and Elections Committee, the Virginia Flora Committee, Science Advisory Committee, the Science Education Committee, and the Archives Committee, and the duties of the Standing Committees not specified hereafter, shall be as specified in the Academy Bylaws, and as may be further enumerated by Council from time to time.

## ARTICLE IV: THE VIRGINIA JOURNAL OF SCIENCE

The Virginia Journal of Science shall be the official publication of the Virginia Academy of Science. All Academy members shall receive copies of this publication.

## ARTICLE V: FELLOWS

From active membership, there shall be a body of scholars known as "Fellows of the Virginia Academy of Science" selected because of their contribution to science in one or more of the following ways: (a) outstanding scientific research, (b) inspirational teaching of science, (c) significant leadership in the Academy. Rules and procedures for selection of Fellows shall be specified in the Academy Bylaws.

## ARTICLE VI: ACCREDITATION OF MEMBERSHIP

Membership of the Academy shall be accredited by the Secretary and the Treasurer. The membership list shall be published periodically according to types, as directed by Council.

## ARTICLE VII: COMPOSITION AND RESPONSIBILITIES OF COUNCIL

\*\*

Section 1. Council shall be composed of the President, the President-elect, the Secretary, the Treasurer, the three most recent Past Presidents and one member elected by each Section of the Academy. Members from the Sections shall be elected for three year terms on a rotational basis among the Sections, provided the initial term of a member from a newly established Section shall be specified by Council. In addition to the foregoing, the Chairmen of the Standing Committees, the Editor of the Virginia Journal of Science, and Visiting Scientists Program Director shall be members of Council. In event of vacancies, the President shall make interim appointments until the next election is held; provided however, vacancies of elected officers shall be filled as hereafter provided.

Section 2. Council shall meet each year preceding the annual meeting and at least once in the fall at a time and place designated by the President.

Section 3. Twelve members shall constitute a quorum for the transaction of business by Council.

Section 4. Council shall establish the policies of this organization and shall be responsible for the administration of all Academy funds.

Section 5. Council shall consider and recommend to the membership from time to time appropriate changes in the Constitution, and shall promulgate bylaws appropriate to the implementation of the Constitution.

Section 6. Council may establish appropriate administrative positions and employ such personnel as may be required. Terms of office, the duties and remuneration of such personnel shall be prescribed by Council.

Section 7. Through appropriate Bylaws, Council shall provide for the publication of the Virginia Journal of Science.

Section 8. The Executive Committee of Council shall be empowered to act for Council on an interim basis between meetings of Council and shall report to Council at its regular meetings. A meeting of Council may be called at any time upon concurrence of any four members of the Executive Committee.

#### ARTICLE VIII: MEETINGS AND BUSINESS

Section 1. The annual meeting of this organization shall be arranged in accordance with procedures to be established by Council in appropriate Academy Bylaws.

Section 2. All business requiring action by the membership shall be transacted at an Academy Conference, which shall be scheduled by Council during the annual meeting. A meeting of the Academy Conference may be called between Annual Meetings by concurrence of a majority of the members of Council; provided, however, that the membership shall be notified of such called meeting no less than 30 days prior to the date that such meeting is to be held. Forty accredited members shall constitute a quorum for the transaction of business by an Academy Conference.

Section 3. Each section shall annually arrange a program oriented to its area of scientific interest; provided, however, such programs shall be compatible with the purpose of the Academy and scheduled within the framework of the general meeting program of the Academy.

Section 4. The fiscal year of the Academy shall be from January 1 through December 31.

Section 5. The parliamentary procedure for all meetings of this organization shall be governed by Robert's Rules of Order Revised, and Council shall provide for a Parliamentarian.

#### ARTICLE IX: ESTABLISHMENT OF SECTIONS

Section 1. Sections as defined in Article III with the approval of Council, may be organized by an accredited group of members. Each Section shall annually arrange a scientific program related to its area of interest.

Section 2. Such a section may become accredited and established after it has conducted one successful program at an annual meeting of the Academy.

Section 3. Any Constitution and Bylaws changes proposed by a Section must conform to the provisions of the Academy Constitution and Bylaws and shall be submitted to Council for review and approval prior to adoption by Section.

Section 4. Any Section which fails to conduct a program at two successive Academy annual meetings, may be dropped as a Section by action of Council; but, may be reinstated after subsequently conducting one successful program.

Section 5. When established, all Section names shall be enumerated in the Academy Bylaws, and thereby subject to provisions of Article XIII, Section 1.

#### \*\*\*\* ARTICLE X: ELECTION OF ACADEMY AND SECTION OFFICERS

Section 1. A "Nominations and Elections Committee" consisting of three recent Past Presidents, appointed by the President shall establish a slate of nominations for the positions of President-elect, Secretary and Treasurer and conduct an election for same in accordance with procedures specified by Academy Bylaws.

Section 2. Upon election, such officers shall serve one-year terms commencing at the annual meeting at which their election is announced and continuing until the next annual meeting; provided, however, the President-elect shall automatically ascend to the position of President at the end of this scheduled term of office or at any prior time that the office of President may be vacated; however, such person shall not serve as President beyond the term that such person was originally scheduled to serve.

Section 3. All interim vacancies in Academy offices, other than president, occurring between annual Academy Conferences, shall be filled by Council from names of persons recommended by the Executive Committee. Persons so selected shall serve until the next Academy Conference.

Section 4. Each Section shall elect from their members:

- A. A Chairman, and a Secretary for one-year terms of office.
- B. A representative to Council in accordance with the provisions of Article VII.
- C. Other officers desired.

Section 5. Persons to fill vacancies in Section offices which occur between Annual Meetings, shall be designated by the Council Representative from that Section.

Section 6. All Elected officers shall serve without remuneration, but, at the discretion of Council, may be reimbursed for certain expenses incurred in conduction the business of the Academy.

#### ARTICLE XI: COMMITTEE STRUCTURE, APPOINTMENTS, TERMS, ETC.

Section 1. Except as provided otherwise, all Standing Committees shall be composed of 3 or more members, and the President shall designate Committee Chairmen, and appoint approximately one-third of the members of each Committee for terms of 3 years, and shall subsequently appoint members to fill unexpired terms that occur periodically.

Section 2. The Research Committee shall be composed of five (5) members, each appointed for a term of five (5) years. One new member shall be appointed each year by the President to replace the member whose term expires; unexpired terms shall also be filled by appointment by the



President. The senior member of the Committee shall be Chairman.

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Section 3. A Trust Committee, composed of three accredited members, shall be elected by Council, to serve for terms of three years on a rotational basis. The members of this Committee shall place in trust and supervise the management of Academy investments subject to annual review by Council. The Committee shall elect its own Chairman; provided, however, that should it be unable to do so, the President shall name the Chairman.

Section 4. The President and Council shall assign operational matters to appropriate Standing Committees; however, the President and/or Council may establish Special Committees as the need arises.

#### ARTICLE XII: JUNIOR ACADEMY OF SCIENCE

The Academy shall provide financial support, leadership, and supervision to a Junior Academy of Science. Effective working relationships shall be maintained with such Junior Academy of Science, through the Junior Academy of Science Committee.

#### ARTICLE XIII: BYLAWS AND AMENDMENTS

Section 1. Council shall promulgate appropriate Bylaws to implement or further clarify the Articles of this Constitution. The establishment or amendment of such Bylaws shall require an affirmative vote of a majority of the total membership of Council; provided, that all proposed Bylaws or amendments shall be distributed to the membership or published in an issue of the Virginia Journal of Science at least 30 days prior to action by Council.

Section 2. This Constitution may be changed or amended, after the recommendation of a majority of the total membership of Council, by a two-thirds majority of an Academy Conference, provided all proposed changes shall be submitted to members of Council in writing no less than 15 days prior to the Council Meeting at which such proposals are to be considered and further provided that subsequent to approval by Council, all proposed amendments shall be published in the Virginia Journal of Science or distributed in writing to the membership no less than 25 days nor more than 50 days prior to presentation to an Academy Conference for adoption.

Section 3. All provisions of the Constitution and Bylaws in effect prior to the adoption of this Constitution, except the provisions of this Article, shall rule until new Bylaws are duly established in accordance with Section 1 of this Article.

#### ARTICLE XIV: ARTICLES OF INCORPORATION

The Articles of Incorporation of this organization (Charter) shall conform to the provisions of this Constitution and all amendments hereafter adopted. The Constitution and Bylaws Committee shall review and coordinate all necessary appropriate revisions of both documents and be responsible for the submission of all required reports to the State Corporation Commission and other governmental entities, annually or as otherwise required by law.

## ARTICLE XV: DISSOLUTION OR LIQUIDATION

Section 1. In the event of dissolution or liquidation, all liabilities and obligations of the Academy shall be paid, satisfied and discharged.

Section 2. All assets remaining, including those received and held for scientific and educational purposes, shall be transferred to one or more societies or organizations engaged in activities substantially similar to those of the Academy; provided however, that no assets shall accrue to the benefit of any officer or member of the Academy.

\* Approved by Academy at 1970 Annual Meeting. Subsequent changes are indicated as follows:

\*\* Amended May, 1975

\*\*\* Amended May, 1976

\*\*\*\* Amended May, 1980

\*\*\*\*\* Amended May, 1986

## BYLAWS OF VIRGINIA ACADEMY OF SCIENCE

## ARTICLE 1: TYPES OF MEMBERSHIP AND DUES

Section 1. There shall be eight types of members, regular, student, contributing, sustaining, life, patron, honorary life, and business.

Section 2. Dues of the first 4 types of members shall be as follows:

- (1) Regular members shall pay annual dues of twenty-five dollars (\$25.00).
- (2) Student members shall pay annual dues of ten dollars (\$10.00).
- (3) Contributing members shall be individuals who elect to pay annual dues of thirty dollars (\$30.00).
- (4) Sustaining members shall be individuals who elect to pay annual dues of fifty dollars (\$50.00) or more, and institutions which shall pay annual dues of one hundred dollars (\$100.00) or more.
- (5) To be in good standing the foregoing types of members must pay the specified dues by July 1.

Section 3. Life members shall be individuals who elect to pay to the Academy the sum of three hundred dollars (\$300.00) and thereby become exempt from further payment of dues.

Section 4. Patrons shall consist of those persons who have given to this organization the sum of one thousand dollars (\$1,000.00) or its equivalent in property. They shall have all the rights and privileges of regular members and shall be exempt from dues. An institution may also become a patron by meeting the above requirement. Its representative shall have all the rights and privileges of regular members.

Section 5. Honorary Life members shall consist of persons elected by the Council for long and distinguished service to science. They shall have all the rights and privileges of regular members and shall be exempt from dues. Previous active membership in this organization shall not be a requirement of eligibility.

Section 6. Business or industrial organizations, which elect to pay dues of one hundred dollars (\$100.00) annually, shall be Regular Business Members of the Academy, or may elect to:

- A. Pay annual dues of three hundred dollars (\$300.00) and be designated Contributing Business Members, or
- B. Pay annual dues of five hundred dollars (\$500.00) and be designated Sustaining Business Members.

## ARTICLE II: DUTIES OF OFFICERS

Section 1. The President shall be the directing head of the Academy, shall preside at business meetings and general sessions of the organization, and shall appoint the members of the standing committees and of new committees authorized by the Council, in accordance with Article XI of the Constitution.

Section 2. The President-elect shall assist the President as mutually agreed between them, shall serve as president in the latter's absence, and shall be responsible for coordinating the scientific programs of the Annual Meeting. He shall furnish the Academy at its Annual Conference with a list of committee memberships which he has set up to assist him during his year as President.

Section 3. The Secretary shall be responsible for keeping complete records of the Academy Conference and all meetings of the Council and Executive Committee.

Section 4. The Treasurer shall:

- A. Account for the income and disbursements through one Academy General Fund Account.
- B. Keep the membership lists of the Academy up-to-date.
- C. Upon request, supply the Secretary and others a list of all members in good standing.
- D. Receive and disburse all funds as approved by Council and directed by the President or Chairman of the Finance Committee.
- E. Submit to Council annually a written report of all receipts and disbursements, accompanied by a statement of audit from a certified public accountant.
- F. Furnish quarterly financial summaries to the Executive Committee, members of Council, and to members of the Finance Committee.
- G. Prepare annually and present to the Finance and Endowment Committee for review a proposed budget for Academy operations.

Section 5. The Treasurer and all administrative employees engaged in the receipt and disbursement of funds shall be adequately bonded.

Section 6. All officers shall be ex-officio members of all Academy Committees.



## ARTICLE III: DUTIES OF STANDING COMMITTEES

## Section 1. Research Committee shall:

- A. Review and award Academy Research Grants.
- B. Arrange for and present the J. Shelton Horsley Research Award.

## Section 2. Long Range Planning Committee shall:

- A. Develop and advise Council on broad policies which will affect the Academy in the future.
- B. Solicit and study suggestions from the membership for the improvement of Academy activities.
- C. Investigate and evaluate proposed projects, publications and other factors that may relate to the long-range effectiveness of the Academy.
- D. Advise and consult with other Academy Committees relative to the foregoing and make recommendations to such committees concerning the effectiveness of their various activities.

## Section 3. The Junior Academy of Science Committee shall:

- A. Provide Director for Junior Academy of Science.
- B. Coordinate activities of Junior Academy of Science including annual meeting.
- C. Prepare V.J.A.S. budget and submit to V.A.S. Finance Committee by September 1.
- D. Prepare National Science Foundation proposal and submit to Executive Committee by October 1.
- E. Publish and distribute Proceedings of V.J.A.S. by October 1.
- F. Select two student representatives to attend American Junior Academy of Science.
- G. Solicit membership and participation in Junior Academy programs and projects.
- H. Select students for V.A.S. and A.A.A.S. Honorary Membership Awards.
- I. Select recipient of Outstanding Science Teacher Award.
- J. Select recipient of V.J.A.S. Distinguished Service Award.
- K. Select students to present papers to Senior Academy Sections.
- L. Support and participate in all other programs and activities related to the work of V.J.A.S.
- M. Canvass colleges and universities for scholarships available to Science Talent Search Finalists.
- N. Forward list of available scholarships to all high schools sponsors that have requested applications for the Westinghouse Science Talent Search.
- O. Secure list of Virginia contestants from Science Clubs of America and establish a committee to select best 45 papers.
- P. Set up procedures for selecting the top 15 students and declare and announce them to be State Winners in the Virginia Science Talent Search, and all other contenders as runners-up.
- Q. Send names of winners and runners-up to colleges and universities in Virginia.

## Section 4. Membership Committee shall:

- A. Make recommendations to Council, the Executive Committee and officers relative to policies on general membership.
- B. Promote membership growth and seek adequate representation from all scientific disciplines.

- C. Sponsor a Business Advisory Committee for the purpose of creating understanding between science and business, and to solicit business memberships to the Academy.

Section 5. Finance and Endowment Committee shall:

- A. Monitor and appraise income and expenditures, and make appropriate recommendations to the President, Executive Committee and Council.
- B. Estimate annually the anticipated income of the Academy and prepare a proposed budget for consideration by Council at its Fall meeting.
- C. Seek and encourage the establishment of endowments to the benefit of Academy activities.
- D. At least one member of this Committee shall be a member of the Trust Committee.

Section 6. The Trust Committee shall:

- A. Place in trust and supervise the management of funds of the Academy designated by Council or otherwise for investment.
- B. Review all Academy investments annually and make appropriate adjustments subject to approval of Council.

Section 7. The Publications Committee shall:

- A. Develop and implement a continuing policy of review and evaluation of Academy publications.
- B. Present to Council annually through the Finance Committee the budgetary needs of the several Academy periodical publications.
- C. Make recommendations to Council relative to priority, publication, finance and distribution of non-recurring publications.
- D. Select and recommend to Council, as necessary; an Editor for the Virginia Journal of Science, and members of the editorial Board.
- E. Enlist the interest of all groups in worthwhile publications by the Academy.

Section 8. The Awards Committee shall:

- A. Select recipients of the Ivey F. Lewis Distinguished Service Award to be presented periodically to a member who has made significant contributions toward the activities of the Virginia Academy of Science.
- B. Select recipients of Special Awards periodically as directed by Council.
- C. Accept and submit to Council nominations for fellows in accordance to Article V of the Constitution and Article V of the Bylaws.

Section 9. The Fund Raising Committee shall from time to time at the direction of Council, plan, organize, and coordinate appropriate fund raising campaigns in support of Academy activities or projects contingent to the purposes of the Academy.

Section 10. Nominations and Elections Committee shall:

- A. Mail to the membership on or about January 1 each year a request for nominations of persons to fill the offices of President-elect, Secretary and Treasurer.
- B. Nominate a slate of two persons for each of the aforementioned offices and present report to Council for informational purposes.

- C. Mail slate of nominees to members advising that names may be added to the slate by 25 members petitioning the committee on behalf of each name to be added.
- D. Prepare ballots with or without additional nominees as the case may be and mail to membership with registration and other information relative to annual meeting indicating deadline and address for return of ballot to committee.
- E. Count ballots and announce results at the Academy Conference. Should a tie vote result for any office, the Academy Conference shall vote on the nominees. In all cases, the nominee receiving the largest number of favorable votes shall be elected; provided, however, that only members in good standing may cast ballots.

\*\*\* Section 11. The Constitution and Bylaws Committee shall:

- A. Periodically receive and prepare drafts of all proposed changes in constitution as the occasion arises and present same to Council and membership for consideration as set forth in the constitution.
- B. Draft all bylaw changes as directed by Council and notify membership of such changes.
- C. Update articles of Incorporation (Charter) as required.
- D. Provide a Parliamentarian for all Council meetings and Academy Conferences.

\*\*\*\* Section 12. The Virginia Flora Committee shall:

- A. Promote the study of and publications of the flora and vegetation of Virginia.
- B. Sponsor symposia and conferences on the ecology, conservation, and preservation of the plant life of Virginia.
- C. Disseminate botanical information to all who are interested in the flora and ecology of Virginia.
- D. Serve as liaison between the Academy, government bodies, and institutions in matters pertaining to the plant life of Virginia.

Section 13. The Science Advisory Committee Shall:

- A. Provide scientific and technical information and advice requested by the Executive, Legislative, and other governmental bodies and agencies of the Commonwealth of Virginia.
- B. Serve as liaison for the collection and transfer of scientific information and/or advice solicited in (A).
- C. Collect and evaluate suggestions and opinions regarding topics of general public interest wherein science and technology may provide assistance, but where such assistance has not been requested. The Science Advisory Committee will make recommendations to the Academy, to the Executive Committee, and/or the Council of the Academy for review and approval. The Science Advisory Committee, upon direction of Council or Executive Committee, shall serve as a conduit for placement of such information before the appropriate Executive, Legislative, or other governmental body or agency.
- D. Maintain an inventory of scientific interests and expertise of individuals within the Academy who are willing to serve in an advisory and/or consultant capacity to state government.



- E. At no time operate beyond constraints considered as proper conduct for a non-profit organization.
- F. Append all reports and recommendations with a statement as follows; "The Virginia Academy of Science assumes no legal or financial responsibility for the utilization or dispersal of scientific and technical data or advice provided by the science Advisory Committee, further, the Academy assumes no responsibility, financial or other wise, to governmental agents or agencies, institutions, individuals or committee members pursuant to the conduct and activities of this committee.

\*\*\*\*

## Section 14. The Science Education Committee shall:

- A. Promote science education in the State of Virginia.
- B. Disseminate information about scientific matters and scientific topics of current interest.
- C. Respond to requests for assistance in matters dealing with education in the areas of mathematics and science, such as are embraced by the various Academy Sections and as directed by the President and Council of the Academy.
- D. Assist and cooperate with the Virginia State Department of Education in planning and conducting the annual State Science Teachers Conference, K-12. Delegated members of the Committee may hold and be responsible for funds generated by the activities of the State Science Teachers Conference, solely for the purpose of funding the Conference meetings. These funds shall remain separate from other funds of the Academy.

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Section 15. The Archives Committee shall address the business of collection, assembly, organization, cataloguing and storage of records, documents, awards and paraphernalia associated with the history and development of the Academy; and, in support of this:

- A. Secure an institutional repository for storage of the inactive records of the Academy.
- B. Secure the services of a qualified individual to establish and maintain the aforementioned records, as the official Archivist of the Academy; and such person shall be extended honorary membership in the Academy; and,
- C. Assist, and cooperate, with the Archivist in securing and screening of records and documents destined for permanent storage in the Archives.

## ARTICLE IV: VIRGINIA JOURNAL OF SCIENCE

Section 1. The Academy shall publish the Virginia Journal of Science quarterly.

Section 2. The staff of the Virginia Journal of Science shall be composed of:

- A. An editor recommended by the Publications Committee and appointed by Council for a three-year term.
- B. Such Associate Editors, Assistant Editors, or Editorial Board Members, appointed by the President, as are recommended by the Editor and the Publications Committee.
- C. Editors designated by individual Sections.

Section 3. All members of the Academy shall receive the Virginia Journal of Science.

Section 4. Subscriptions may be sold to non-members at a rate established by the Publications Committee and approved by Council.

#### ARTICLE V: RULES AND PROCEDURES FOR SELECTING FELLOWS

Section 1. A "Fellow" must be nominated by at least three members of the Academy. The Academy Council must approve each Fellow by a majority vote. It will be the usual procedure to announce new Fellows at an Annual Meeting.

## Section 2. Nominations for Fellows with appropriate biographical information shall be sent directly to the Executive-Treasurer annually prior to October 1. All information received shall be forwarded to the Chairman of the Awards Committee for review and recommendations to Council prior to the subsequent Annual Meeting. All nominees not recommended by the Committee or not acted upon favorably by Council shall remain in consideration for one additional year.

## Section 3. No more than twenty-five fellowships will be approved the first year. After the first year, no more than one-half of one percent of the total active membership shall be selected in any one year. The limiting number of Fellows shall not exceed five percent of the total active membership of the Academy. However, nothing in this section shall preclude the election of one fellow each year.

Section 4. All Fellows shall be presented with a suitably inscribed scroll.

Section 5. Appropriate announcement of new Fellows shall be made in the Virginia Journal of Science.

#### ARTICLE VI: THE DULY ORGANIZED SCIENTIFIC SECTIONS OF THE ACADEMY ARE:

- (1) Agricultural Sciences
- (2) Astronomy, Mathematics and Physics
- (3) Microbiology
- (4) Biology
- (5) Chemistry
- (6) Materials Science
- (7) Engineering
- (8) Geology
- (9) Medical Sciences
- (10) Psychology
- (11) Education
- (12) Statistics
- (13) Aeronautical and Aerospace Sciences
- (14) Botany
- (15) Environmental Science

#### ARTICLE VII: OFFICIAL REPRESENTATION OF THE ACADEMY

Where official representation of the Academy is desirable the President or his designates shall represent the Academy. No officer or other Agency member shall receive reimbursement from Academy funds for such purposes, except that actual expenses of the Academy representatives in attending the annual meeting of the American Association for the Advancement of Science may be

paid, subject to the funds provided in the budget by the Finance Committee.

#### ARTICLE VIII: MEETINGS AND BUSINESS

The annual meeting of this organization shall be held in the Spring of each year at a time and place selected by Council, which shall arrange for all appropriate sessions.

#### ARTICLE IX: EXECUTIVE SECRETARY-TREASURER

Section 1. The position of Executive Secretary-Treasurer is hereby established for the purpose of providing administrative assistance to the officers and committee chairmen.

Section 2. The Executive Committee shall select a qualified person for this position, specify his duties, and set appropriate remuneration which shall be approved by Council.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

Section 4. The incumbent of this position shall attend all Council and Executive Committee Meetings and may participate in all deliberations as circumstances dictate, but, shall not have a vote in either body.

#### ARTICLE X: VISITING SCIENTISTS PROGRAM DIRECTOR

Section 1. The position of Visiting Scientists Program Director is hereby established for the purpose of implementing a Visiting Scientists Program in cooperation with the State Board of Education.

Section 2. The Executive Committee upon recommendation of the President shall select a qualified person for this position and approve guidelines for the conduct of the program.

Section 3. The incumbent of this position shall serve at the pleasure of the Executive Committee, subject to review by Council.

\*\*\* Ammended May, 1976

\*\*\*\* Ammended May, 1980

\*\*\*\*\* Ammended May, 1986

## Ammended March, 1988



58      **Membership List — February 1988****Individual - Regular**

ABAYASEKARA, DILIP R. 104 SOCIETY PARK COURT EMMAUS, PA 18049-4214		ANDERSON, JAMES C. CENTRAL VA MARKET SCHOOL 3020 WARDS FERRY ROAD LYNCHBURG, VA 24502	15	BARKER, R. EDWARD JR. UNIV. OF VA., DEPT. OF MAT. SCI. THORNTON HALL CHARLOTTESVILLE, VA 22903	6
ADAMKIEWICZ, LAURA GEORGE MASON UNIVERSITY DEPT OF BIOLOGY FAIRFAX, VA 22030	4	ANDERSON, SAMUEL 6332 BARTMOUTH WAY VIRGINIA BEACH, VA 23464	5	BARNES, DENNIS W. 12 GILDERLEEVE ROAD CHARLOTTESVILLE, VA 22903	5
ADAMS, ARTHUR A. III VIRGINIA MILITARY INSTITUTE DEPARTMENT OF PHYSICS LEXINGTON, VA 24451	2	ANDREWS, ROBERT L. 2018 GROVE AVE RICHMOND, VA 23220	12	BARNETT, LEWIS B. VPI 126 WILLIAMS HALL BLACKSBURG, VA 24061	4
ADAMS, HAROLD S. MTD RT BOX 61-A CLIFTON CIRCLE CLIFTON FORGE, VA 24422	14	ARMBRUSTER, HORST VCU DEPT OF PHYSICS, BOX 2000 RICHMOND, VA 23284	2	BARRA, ROSEMARY MARY WASHINGTON COLLEGE DEPT. OF BIOLOGICAL SCIENCES FREDERICKSBURG, VA 22401	9
ADAMSON, ALICE L. 4904 SPRINGBROOK DRIVE ANNANDALE, VA 22003	2	ATKINS, ROBERT C. JAMES MADISON UNIVERSITY DEPARTMENT OF CHEMISTRY HARRISONBURG, VA 22807	5	BATES, ROBERT C. VPI-SU DEPARTMENT OF BIOLOGY BLACKSBURG, VA 24061	3
AGUIRRE, JOHN T. 626 W OCEAN VIEW AVE B NORFOLK, VA 23503	2	AUKLAND, ELVA D. 2412 N. COLUMBUS AVE ARLINGTON, VA 22207	3	BATIE, ROBERT E. RADFORD UNIVERSITY DEPARTMENT OF BIOLOGY RADFORD, VA 24142	4
AKE, ROBERT L. OLD DOMINION UNIVERSITY DEPARTMENT OF CHEMICAL SCIENCE NORFOLK, VA 23508	5	AUSTIN, HERBERT W. RT. 3, BOX 235 HAYES, VA 23072	9	BAUDIN, ANTON 714 BRODE AVE BLACKSBURG, VA 24060	1
AKERS, R. MICHAEL VPI-SU 2080 ANIMAL SCIENCES BLDG., DAIRY BLACKSBURG, VA 24061	1	AUSTIN, JOHN M. 1001 SEVENTH AVE FARMVILLE, VA 23901	11	BAUER, DAVID F. VIRGINIA COMMONWEALTH UNIVERSITY DEPT OF MATH SCIENCE RICHMOND, VA 23284	12
ALLAN, RICHARD E. RT. 4, BOX 2320 ASHLAND, VA 23005	2	BARBER, CLINTON W. 1101 WEST AVE RICHMOND, VA 23220	5	BAYLES, ROBERT A. NAVAL RESEARCH LABORATORY CODE 6312 WASHINGTON, D. C. 20375	
ALLEN, VIVIAN G. 2510 PLYMOUTH ST BLACKSBURG, VA 24060-8214		BAILEY, CLIFTON 6507 DIVINE ST MCLEAN, VA 22101	12	BEAL, W. E. VPI-SU DEPARTMENT OF ANIMAL SCIENCE BLACKSBURG, VA 24061	1
ALTY, LISA TREVEY WASHINGTON & LEE UNIVERSITY DEPT OF CHEMISTRY LEXINGTON, VA 24450	9	BAIRD, J. REX CLINCH VALLEY COLLEGE DEPARTMENT OF BIOLOGY WISE, VA 24293	14	BECK, JAMES D. 1977 WESOMDER RD PETERSBURG, VA 23805	5
AMENTA, DONNA S. 110 CRESCENT DRIVE HARRISONBURG, VA 22801	5	BANKS, DAVID A. 3288 PAGE AVE., #403 VIRGINIA BEACH, VA 23451	14	BECK, RUTH A. COLLEGE OF WILLIAM AND MARY DEPT. OF BIOLOGY WILLIAMSBURG, VA 23185	4
AMENTA, RODDY V. 110 CRESCENT DRIVE HARRISONBURG, VA 22801	8	BANKS, CHARLEY W. 3107 BRETTON COURT GLENN ALLEN, VA 23060	4	BELL, CHARLES E. JR. OLD DOMINION UNIVERSITY NORFOLK, VA 23508	5
AMMERMAN, DON J. 5 CEDAR LANE KING GEORGE, VA 22485	2	BARBARO, RONALD D. 7036 LEE PARK COURT FALLS CHURCH, VA 22042	15	BELL, HAROLD M. 708 CIRCLE DR BLACKSBURG, VA 24060	5
ANDERSON, BRUCE W. 1013 HIGHLAND CIRCLE BLACKSBURG, VA 24060	5	BARBER, PATRICK G. RT. 2, BOX 29-B KEYSVILLE, VA 23947	5	BENNECHE, PAUL E. UNIV. OF VA., DEPT. OF NUC. ENG. REACTOR FACILITY - THORNTON HALL CHARLOTTESVILLE, VA 22901	7

BENNETT, JAMES I. 2420 EDMOND DR RICHMOND, VA	7	23228	BLISS, D. CRANDALL 322 SUMMIT STREET LYNCHBURG, VA	14	24503	BRADLEY, TED GEORGE MASON UNIVERSITY BIOLOGY DEPARTMENT FAIRFAX, VA	14	22030	59
BENTLEY, MICHAEL L. 540 DEWEY STREET EVANSTON, IL	11	60202	BLOIS, MARION C. NORTHERN VA COMM COLLEGE, BIOL SCI 6901 SUDLEY ROAD MANASSAS, VA	4	22110	BRANDT, EDWARD E. SHENANDOAH COLLEGE WINCHESTER, VA	3	22601	
BENTZ, EDWARD J. JR. 7915 RICHFIELD RD SPRINGFIELD, VA	15	22153	BOARD, JOHN A. MEDICAL COLLEGE OF VIRGINIA BOX 34, MCV STATION RICHMOND, VA	9	23298	BRAUN, WARREN L. 680 NEW YORK AVE HARRISBURG, VA	7	22801	
BERG, LILLIAN D. 3319 DAUPHINE DR FALLS CHURCH, VA	5	22042	BOAZ, NOEL T. VIRGINIA MUSEUM OF NAT. HISTORY 1001 DOUGLAS AVE MARTINSVILLE, VA	4	24112	BREEN, TIMOTHY J. MEDICAL COLLEGE OF VIRGINIA DEPARTMENT OF BIOSTATISTICS RICHMOND, VA	12	23298	
BERGSTROM, PETER W. DEPT. OF BIOLOGY WASHINGTON AND LEE UNIVERSITY LEXINGTON, VA	4	24450	BODKIN, MORLYN L. JAMES MADISON UNIVERSITY DEPARTMENT OF BIOLOGY HARRISONBURG, VA	14	22807	BREIL, DAVID A. LONGWOOD COLLEGE DEPARTMENT OF NATURAL SCIENCE FAIRVILLE, VA	14	23901	
BETTENHAUSEN, LEE H. 7 LONG LANE MALVERN, PA	7	19355	BOGESS, ROBERT K. RADFORD UNIVERSITY DEPT. OF CHEMISTRY RADFORD, VA		24142	BRENIZER, JACK S. JR UNIVERSITY OF VIRGINIA DEPT NUC ENG & ENG PHYSICS CHARLOTTESVILLE, VA	7	22901	
BEVAN, DAVID R. VPI-SU, DEPT. OF BIOCHEMISTRY & NUTRITION BLACKSBURG, VA	9	24061	BOND, JUDY MEDICAL COLLEGE OF VIRGINIA DEPARTMENT OF BIOCHEMISTRY RICHMOND, VA	9	23298	BREWER, WILLIAM D. RT. 4, BOX 360 HAYES, VA	13	23072	
BICE, RAYMOND C. JR. 1720 KING MOUNTAIN RD CHARLOTTESVILLE, VA	10	22901	BOOTS, MARVIN R. MEDICAL COLLEGE OF VIRGINIA BOX 581, MCV STATION RICHMOND, VA		23298	BROOKS, G. R. DEPT. OF BIOLOGY COLLEGE OF WILLIAM AND MARY WILLIAMSBURG, VA	4	23185	
BICK, KENNETH F. COLLEGE OF WILLIAM AND MARY DEPARTMENT OF GEOLOGY WILLIAMSBURG, VA	8	23185	BOYARD, K. P. V.P.I. & S.U. ANIMAL SCIENCE DEPT BLACKSBURG, VA	1	24061	BROWN, DAVID A. 6133 HERRIFIELD DRIVE RICHMOND, VA	5	23225	
BINNS, STEPHEN J. 46 RODMAN RD RICHMOND, VA	14	23224	BOWEN, JACOB VAN JR. 1714 BLOOMFIELD ROAD RICHMOND, VA	12	23225	BROWN, KENNETH G. OLD DOMINION UNIVERSITY DEPT. OF CHEMISTRY NORFOLK, VA	5	23508	
BIRD, SAMUEL O. 4400 BROMLEY LANE RICHMOND, VA	8	23221	BOWKER, DAVID E. NASA - LANGLEY RES CTR M.S. 473 HAMPTON, VA	13	23665	BROWNE, JOSEPH E. 1060 MANCHESTER AVE NORFOLK, VA	4	23508	
BISHARA, MICHAEL M. 23 VALLEY VIEW DRIVE ABINGDON, VA	7	24210	BOWMAN, RICHARD L. BRIDGEWATER COLLEGE DEPT OF PHYSICS BRIDGEWATER, VA	2	22812	BRUBAKER, KENTON K. EASTERN MEMPHIS COLLEGE HARRISBURG, VA	1	22801	
BISHOP, JOHN W. UNIVERSITY OF RICHMOND DEPARTMENT OF BIOLOGY RICHMOND, VA	15	23173	BOYD, JAMES M. 4634 BUTTE ROAD RICHMOND, VA	2	23235	BUICKER, ARTHUR L. VPI-SU DEPARTMENT OF BIOLOGY BLACKSBURG, VA	4	24061	
BLAIR, CARVEL HALL OLD DOMINION UNIVERSITY DEPARTMENT OF OCEANOGRAPHY NORFOLK, VA	15	23508	BOZDOGAN, HAMPARSUM UNIVERSITY OF VIRGINIA DEPT. OF MATH, MATH/ASTRO. BLDG. CHARLOTTESVILLE, VA	2	22903	BULL, ALICE LOUISE HOLLINS COLLEGE HOLLINS, VA	4	24020	
BLANTON, JEFFREY M. RT. 2, BOX 602 KING GEORGE, VA	13	22485	BRACHMAN, RUSSELL C. 139 PENDLETON RD DANVILLE, VA	4	24541	BULMER, WALTER NORTHERN VIRGINIA COMM. COLL. ANNANDALE CAMPUS ANNANDALE, VA		22003	
BLEASE, ALFRED D. 2415 OREGON AVENUE, S.W. ROANOKE, VA	2	24015	BRADLEY, ERIC L. WILLIAM AND MARY DEPARTMENT OF BIOLOGY WILLIAMSBURG, VA	4	23185	BUMP, CHARLES M. HAMPTON INSTITUTE P.O. BOX 6483 HAMPTON, VA	5	23668	

BUONCRISTIANI, A. MARTIN 50 SHOE LANE NEWPORT NEWS, VA 23606	2	CHINNICI, JOSEPH P. VA. COMMONWEALTH UNIVERSITY DEPARTMENT OF BIOLOGY RICHMOND, VA 23284	4	COLLINS, JAMES M. M.C.V., BIOCHEMISTRY DEPT BOX 727, MCV STATION RICHMOND, VA 23219	4
BURGER, CAROL J. COLLEGE OF VET. MED., VPI & SU PHASE II, SOUTHGATE DR BLACKSBURG, VA 24061	3	CHLEBOWSKI, JAN F. BIOCHEMISTRY DEPT, MCV-VCU BOX 614 MCV STATION RICHMOND, VA 23298-0614	4	COLLINS, PETER L. OIA ATTN: VP-TPO WASHINGTON, DC 20340-6537	2
BURKHART, HAROLD E. DIV. OF FORESTRY & WILDLIFE SCI. V.P.I. & S.U. BLACKSBURG, VA 24061	1	CLARK, ALLEN K. OLD DOMINION UNIVERSITY DEPARTMENT OF CHEMISTRY NORFOLK, VA 23508	5	COLMANG, GERRILLE VPI-SU COLL. VET. MED. DEPT. OF VETERINARY BIOSCIENCES BLACKSBURG, VA 24061	9
BUTTERMORE, DONALD O. 1519 N. UTAH STREET ARLINGTON, VA 22207	11	CLARK, VICKI PRICE RT. 1, BOX 179 H LANEVA, VA 23089	11	COLUCCI, STEPHEN J. UNIVERSITY OF VIRGINIA DEPT OF ENVIRONMENTAL SCIENCE CHARLOTTESVILLE, VA 22903	15
CAIRNS, JOHN JR. V.P.I. & S.U. CENTER FOR ENVIRONMENTAL STUDIES BLACKSBURG, VA 24061	4	CLARKE, ALEX M. 7707 HOLLINS RD RICHMOND, VA 23229	9	COMLEY, JAMES F. 1614 TRAILBRIDGE ROAD CHARLOTTESVILLE, VA 22903	8
CAMPBELL, F. HOWARD III JAMES MADISON UNIVERSITY DEPARTMENT OF GEOLOGY HARRISONBURG, VA 22807	8	CLARKE, GARY A. ROANOKE COLLEGE DEPARTMENT OF BIOLOGY SALEM, VA 24153	3	CONTA, JAY FRANK 18 NATURAL BRIDGE COURT RICHMOND, VA 23236	8
CARSON, KEITH A. ODU, DEPT OF BIO SCI LAB OF ELECTRON MICROSCOPY NORFOLK, VA 23508-B503	9	CLARKE, LAMBETH M. MESLEYAN DR NORFOLK, VA 23503		CONWAY, ARTHUR F. RANDOLPH MACON COLLEGE ASHLAND, VA. 23005	4
CASAS, JOSEPH C. P.O. DRAWER Y HAMPTON, VA 23666		CLAUS, GEORGE WILLIAM V.P.I. & S.U. DEPARTMENT OF BIOLOGY BLACKSBURG, VA 24061	3	CONWAY, CAROLYN M. VIRGINIA COMMONWEALTH UNIVERSITY BIOLOGY DEPT., BOX 2012 RICHMOND, VA 23284	4
CATON, RANDALL CHRISTOPHER NEWPORT COLLEGE 50 SHOE LANE NEWPORT NEWS, VA 23606	2	CLAY, F. P. JR. OLD DOMINION UNIVERSITY PHYSICS DEPARTMENT NORFOLK, VA 23508	2	COOK, DESMOND C. DEPT. OF PHYSICS OLD DOMINION UNIVERSITY NORFOLK, VA 23508	2
CHAMBERS, BARBARA F. 4220 DANDRIDGE TERRACE ALEXANDRIA, VA 22309	2	CLENCH, STEPHEN C. COLLEGE OF WILLIAM AND MARY DEPARTMENT OF GEOLOGY WILLIAMSBURG, VA 23185	8	COPELAND, G. E. OLD DOMINION UNIVERSITY DEPARTMENT OF PHYSICS NORFOLK, VA 23508	2
CHANDLER, G. W. THE NITCHCROFT 3960 RICHARDSON RD VIRGINIA BEACH, VA 23455		CLIFF, EUGENE M. 207 PRIMROSE DR BLACKSBURG, VA 24060	7	CORLEY, KARL C. JR. MEDICAL COLLEGE OF VA BOX 125, MCV STATION RICHMOND, VA 23219	10
CHAPPELL, EARL B. III 5136 FALLSMEAD DOWNS VIRGINIA BEACH, VA 23464	11	CLOUGH, STUART C. 125 FAIRWOOD DR RICHMOND, VA 23235	5	COSTER, ABRAHAM A. 3541 W. BRADDOCK RD ALEXANDRIA, VA 22302	6
CHAPPELL, MARY R. 5136 FALLSMEAD DOWNS VIRGINIA BEACH, VA 23464	11	COCKINS, N. DEAN JAMES MADISON UNIVERSITY DEPT. OF BIOLOGY HARRISONBURG, VA 22807	14	COTHRON, JULIA M. 2903 CRAIGWOOD CIRCLE MECHANICSVILLE, VA 23111	11
CHAPPELL, WILBERT 705 HICKORY HILL DRIVE HARRISONBURG, VA 22801	5	COLEMAN, PHILLIP H. M.C.V., DEPT. OF MICROBIOLOGY BOX 847, MCV STATION RICHMOND, VA 23219	3	COX, GINA R. 1005 E. BEVERLEY ST STAUNTON, VA 24401	4
CHENEY, RICHARD N. JR. CHRISTOPHER NEWPORT COLLEGE 50 SHOE LANE NEWPORT NEWS, VA 23606	4	COLEMAN, R. A. COLLEGE OF WILLIAM AND MARY WILLIAMSBURG, VA 23185	5	COX, MARY L. 3654 RADFORD ST NORFOLK, VA 23513	8
CHINCHILLI, VERNON M. DEPARTMENT OF BIostatISTICS BOX 32, MCV STATION RICHMOND, VA 23298		COLLINS, ERIC J. WYTHEVILLE COLLEGE DEPARTMENT OF BIOLOGY WYTHEVILLE, VA 24382	4	COX, WILLIAM E. 1903 SHELOR LANE BLACKSBURG, VA 24061	15



COZZENS, ROBERT F. 3009 N. TACOMA STREET ARLINGTON, VA 22213	5	DANIEL JR., JOSEPH C. OLD DOMINION UNIVERSITY COLLEGE OF SCIENCES NORFOLK, VA 23508	4	DICKENS, CHARLES H. II 1103 GLADSTONE PLACE WELLINGTON, VA 22308	11
CRAFTON, HUGH C. JR. 1110 TRENTS FERRY ROAD LYNCHBURG, VA 24503	5	DANIEL, MARGARET F. 21 BOSTWICK LANE RICHMOND, VA 23226	4	DIECCHIO, RICHARD J. GEORGE MASON UNIVERSITY DEPARTMENT OF GEOLOGY FAIRFAX, VA 22030	8
CRAWFORD, JACK A. VPI-SU DEPARTMENT OF BIOLOGY BLACKSBURG, VA 24061	4	DANIEL, VAN W. JR. CLINCH VALLEY COLLEGE WISE, VA 24293	5	DIEML, FRED A. UNIVERSITY OF VIRGINIA DEPARTMENT OF BIOLOGY-GILMER HALL CHARLOTTESVILLE, VA 22901	4
CRAWFORD, EDWARD A. 7075 JUANA DRIVE MILLINGTON, TN 38053	4	DAVIDSON, TERRY L. VA MILITARY INSTITUTE DEPT OF PSYCHOLOGY LEXINGTON, VA 24450	10	DOBEK, BERNARDINE W. 12808 HUNTSMAN WAY POTOMAC, MD 20854	1
CRAWFORD, GEORGE W. 205 JOHN WYTHE PLACE WILLIAMSBURG, VA 23185	2	DAVIES, WILLIAM E. 125 W. GREENWAY BLVD FALLS CHURCH, VA 22046	8	DOMINEY, RAYMOND M. UNIVERSITY OF RICHMOND P.O. BOX 111 RICHMOND, VA 23173	5
CRIM, SAMUELLA H. P.O. BOX B7 NEW MARKET, VA 22844	4	DAVIS, HUBERT J. 403 LEAVELL ROAD PORTSMOUTH, VA 23701		DOMAGHY, JAMES J. WASHINGTON AND LEE UNIVERSITY DEPARTMENT OF PHYSICS LEXINGTON, VA 24451	2
CRISMAN, JUDITH A. MARY WASHINGTON COLLEGE DEPT OF CHEMISTRY FREDERICKSBURG, VA 22401	5	DAVIS, JOHN STAIGE JR. UNIVERSITY OF VA SCHOOL OF MEDICINE CHARLOTTESVILLE, VA 22908	9	DORR, JOHN VAN W. II MRS. 4982 SENTINEL DR. APT. 304 BETHESDA, MD 20816	8
CRITTENDEN, JOHN B. 15 AZALEA DR BLACKSBURG, VA 24060		DEAVER, BASCOM S. JR. UNIVERSITY OF VIRGINIA PHYSICS DEPARTMENT CHARLOTTESVILLE, VA 22904	2	DOWNES, ROBERT W. MEDICAL COLLEGE OF VIRGINIA BOX 111, DEPT. OF MEDICINE, MCV RICHMOND, VA 23219	9
CROCKETT, JOSEPH M. BRIDGEMATER COLLEGE DEPT OF CHEMISTRY BRIDGEMATER, VA 22812	5	DECKER, R. DEAN UNIVERSITY OF RICHMOND BIOLOGY DEPARTMENT RICHMOND, VA 23173	14	DUBERG, JOHN E. 4 MUSEUM DRIVE NEWPORT NEWS, VA 23601	2
CROSS, GERALD H. V.P.I. & S.U. 101 CHEATHAM PLACE BLACKSBURG, VA 24061	4	DEMENTI, PATRICIA L. 7519 OAKMONT DRIVE RICHMOND, VA 23228	4	DUESER, RAYMOND D. UNIVERSITY OF VIRGINIA DEPT OF ENVIRONMENTAL SCIENCES CHARLOTTESVILLE, VA 22903	4
CROUSE, WALTER C. CLINCH VALLEY COLLEGE COLLEGE AVE, DEPT NATURAL SCIENCES WISE, VA 24293	5	DENNIS, DOUGLAS E. JAMES MADISON UNIVERSITY RT 5, BOX 92 HARRISONBURG, VA 22801	3	DUGHI, JEANE J. 812 ST. LUKE ST VIRGINIA BEACH, VA 23455	4
CRUSER, MELVIN E. JR. 5305 LAKESIDE AVENUE VIRGINIA BEACH, VA 23451	2	DENNIS, SALLY D. P.O. BOX 402 SHAWSVILLE, VA 24162	4	DUNCAN, ROBERT L. 8204 NOTRE DAME DRIVE RICHMOND, VA 23228	5
CUPSHACK, STEPHEN G. OLD DOMINION UNIVERSITY MEN DEPT. NORFOLK, VA 23508		DERR, JEFFREY F. V.P.I. AND S.U. DEPT. OF PLANT PATH. PHYS. BLACKSBURG, VA 24061		DUPUY, DAVID L. VIRGINIA MILITARY INSTITUTE DEPARTMENT OF PHYSICS LEXINGTON, VA 24450	2
CURLY, JAMES W. LONGWOOD COLLEGE FARMVILLE, VA 23901	2	DEWEY, LOVELL J. P.O. BOX 899 HOPEWELL, VA 23860	5	DURRILL, PRESTON L. 1309 RADISON STREET RADFORD, VA 24141	5
DAHLGARD, MURIEL 1216 KRISIE CIRCLE LYNCHBURG, VA 24503	5	DEWEY, WILLIAM L. M.C.V., DEPT. OF PHARMACOLOGY BOX 613, MCV STATION RICHMOND, VA 23298	9	De Fur, PETER L. GEORGE MASON UNIVERSITY DEPT. OF BIOLOGY FAIRFAX, VA 22030	4
DANCY, WILLIAM H. ROUTE 4, BOX 308 CHARLOTTESVILLE, VA 22901	2	DEMOLFE, THOMAS E. BOX 133 HAMPDEN SYDNEY, VA 23943	10	EBEL, RICHARD VPI-SU DEPT. OF BIOCHEM. AND NUTRITION BLACKSBURG, VA 24061	9

ECKELIN, RALPH 8333 LITTLE RIVER TURNPIKE ANNANDALE, VA 22003	4	FARRIS, GEORGE L. RT. 1, BOX 273 SALTVILLE, VA 24370	FOSTER, JYDCE G. USDA-ARS-ASMCRL P.O. BOX 867, AIRPORT ROAD BECKLEY, WV 25802-0867	14	
EDMONDS, WILLIAM J. 1610 KENNEDY AVE BLACKSBURG, VA 24060	1	FASHING, NORMAN J. COLLEGE OF WILLIAM AND MARY DEPARTMENT OF BIOLOGY WILLIAMSBURG, VA 23185	4	FOSTER, M. JOHN D. 7807 HILLCREEK DR RICHMOND, VA 23235	5
EDWARDS, CAROLYN 1990 OLD HANOVER ROAD SAMOSTON, VA 23150	9	FICENEC, JOHN R. 1305 GLEN CORE LANE BLACKSBURG, VA 24060	2	FOY, CHESTER L. V.P.I. & S.U. DEPARTMENT OF PLANT PATHOLOGY BLACKSBURG, VA 24061	1
EDWARDS, LESLIE E. 1990 OLD HANOVER ROAD SAMOSTON, VA 23150	9	FINKEL, KARIN N VA COMM COLLEGE, DEPT NAT SCIENCE 8333 LITTLE RIVER TURNPIKE ANNANDALE, VA 22003	14	FRANKO, BERNARD V. A. H. ROBINS RESEARCH LAB SHERWOOD AND RESERVE AVE RICHMOND, VA 23220	9
EISENBACK, J. D. V.P.I. AND S.U. DEPT. OF PLANT PATHOLOGY BLACKSBURG, VA 24061	1	FISHBACK, PAT. O. 2401 HARTMAN STREET RICHMOND, VA 23223	11	FREDRICK, LAURENCE W. UNIVERSITY OF VIRGINIA P.O. BOX 3818 CHARLOTTESVILLE, VA 22903-0818	
ELDER, JOHN H. JR. RT. 10, BOX 452 FREDERICKSBURG, VA 22401	1	FISHER, CHET H. RADFORD UNIVERSITY DEPT. OF PSYCHOLOGY RADFORD, VA 24142	10	FRIEDMAN, RUTH 204 KENT STREET FREDERICKSBURG, VA 22401	
ELBERT, KLAUS D. VPI-SU DEPARTMENT OF BIOLOGY BLACKSBURG, VA 24061	3	FISHER, DEBORAH L. 2218 DRAGONFLY LANE RICHMOND, VA 23235		FRIESEN, W. OTTO UNIVERSITY OF VIRGINIA DEPT BIOLOGY/GILNER HALL CHARLOTTESVILLE, VA 22901	4
ELIAS, WALTER JR. 4223 HICKORY RD ETTRICK, VA 23803	2	FISHER, ROBERT W. VCU PLANT BIOTECH. RESEARCH LAB 816 PARK AVE RICHMOND, VA 23284	4	FRIPP, ARCHIBALD L. 125 LITTLE JOHN ROAD WILLIAMSBURG, VA 23185	6
ELLIS, MARK S. 1353 SURREY CRESCENT WOLFBLK, VA 23508	4	FLINT, FRANKLIN F. RANDOLPH MACON WOMAN'S COLLEGE 2427 INDIAN HILL ROAD LYNCHBURG, VA 24503	4	GARRETT, REGINALD H. UNIVERSITY OF VIRGINIA DEPT OF BIOLOGY, GILNER HALL CHARLOTTESVILLE, VA 22903	4
ELMES, DAVID G. WASHINGTON AND LEE UNIVERSITY DEPARTMENT OF PSYCHOLOGY LEIGHTON, VA 24450	10	FOWES, PAULINE F. 3014 PUTNEY LANE RICHMOND, VA 23228	5	GARRETTSON, L. K. MEDICAL COLLEGE OF VIRGINIA BOX 501, MCV STATION RICHMOND, VA 23298	5
ENGEL, GERALD L. 15 AVON CT NAUGATUCK, CT 06770	2	FONTENOT, J.P. V.P.I. & S.U. DEPARTMENT OF SCIENCES BLACKSBURG, VA 24061	5	GARRISON, NORMAN E. JAMES MADISON UNIVERSITY DEPARTMENT OF BIOLOGY HARRISBURG, VA 22807	
EPPS, THOMAS HENRY 4313 MOREHOUSE TERRACE CHESTERFIELD, VA 23832-7768	5	FORBES, ALLAN L. 11312 FARMLAND DRIVE ROCKVILLE, MD 20852	9	GATES, JAMES E. V.C.U. - BIOLOGY DEPT. 816 PARK AVE RICHMOND, VA 23284	3
ERGLE, WILLIAM D. 5941 CASTLE ROCK ROAD S.W. ROANOKE, VA 24018	2	FORBES, JAMES E. 29 TWIN LAKES CIRCLE HAMPTON, VA 23666		GATHRIGHT, THOMAS VA. DIV. OF MINERAL RESOURCES RFD. L, BOX 135 AFTON, VA 22920	8
ESCOBAR, MARIO R. MEDICAL COLLEGE OF VIRGINIA DEPT OF PATHOLOGY, BOX 106 RICHMOND, VA 23298	3	FORD, GEORGE D. MEDICAL COLLEGE OF VIRGINIA DEPT PHYSIOL, BOX 551 MCV STATION RICHMOND, VA 23298-0551	9	GELLER, E. SCOTT V.P.I. & S.U. PSYCHOLOGY DEPARTMENT BLACKSBURG, VA 24061	10
EKLIN, JOSEPH D. VIRGINIA DEPARTMENT OF EDUCATION POST OFFICE 6-9 RICHMOND, VA 23216	11	FORMICA, JOSEPH V. MEDICAL COLLEGE OF VIRGINIA DEPARTMENT OF MICROBIOLOGY RICHMOND, VA 23298	3	GEISE, RONALD N. COLLEGE OF WILLIAM AND MARY 213 JONES HALL WILLIAMSBURG, VA 23185	11
FALLS, ELSA O. 1515 HELMSDALE DR RICHMOND, VA 23233	4	FOSTER, C. L. JR. 1203 AUGUSTA ST BLUEFIELD, WV 24605	2	GILLESPIE, ROBERT F. JR. POST OFFICE BOX 95 WOODBERRY FOREST, VA 22989	4

GILPIN, BILLY J. 1433 RUTHLAND DR VIRGINIA BEACH, VA 23454		GRETZ, MICHAEL R. GEORGE MASOM UNIVERSITY DEPT. OF BIOLOGY FAIRFAX, VA 22030	14	HAWLEY, CHARLES OVERTON JR. DIVISION OF MAMMALS, NRC-NHB 108 SMITHSONIAN INSTITUTION WASHINGTON, D.C. 20560	4
GOLDMAN, EMMA W. UNIVERSITY OF RICHMOND DEPT. OF CHEMISTRY RICHMOND, VA 23173	5	GROCHOWSKI, TEOFIL JR. 39 MISTLETOE DR FOREST, VA 24551	13	HAPP, JOHN SHENANDOAH COLLEGE AND CONSERVATORY WINCHESTER, VA 22601	
GOLLER, EDWIN J. VIRGINIA MILITARY INST. RFD 5, BOX 21 LEXINGTON, VA 24450	5	GRUNDER, HERMANN A. 12070 JEFFERSON AVE NEWPORT NEWS, VA 23606		HARGIS, WILLIAM J. JR. VA INSTITUTE OF MARINE SCIENCE GLOUCESTER POINT, VA 23062	4
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24153		23230		23518	
JENSEN, DONALD R. V.P.I. & S.U. DEPT. OF STATISTICS BLACKSBURG, VA	12	KAUFFMAN, GLEN M. EASTERN Mennonite COLLEGE HARRISONBURG, VA	5	KIRSCHBAUM, BARRY MEDICAL COLLEGE OF VA BOX 160 RICHMOND, VA	9
24061		22801		23298	
JENSEN, T. A. V.P.I. AND S.U. BIOLOGY DEPT BLACKSBURG, VA	4	KAUZLARICH, JAMES J. UNIV OF VA, DEPT OF MECH ENG UNIVERSITY STATION CHARLOTTESVILLE, VA	7	KIZER, FRANKLIN D. RT 2, BOX 1449 LANCASTER, VA	11
24061		22903		22503	
JESSER, WILLIAM A. UNIVERSITY OF VIRGINIA THORNTON HALL CHARLOTTESVILLE, VA		KEEFE, WILLIAM E. 107 FAIRWAY LANE ASHLAND, VA	5	KLINE, EDWARD S. MEDICAL COLLEGE OF VA BIOCHEMISTRY DEPT RICHMOND, VA	9
22901		23005-3105		23219	
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23185		23173		23219	
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24060		24141		24061	
JOHNSON, JAMES H. MEDICAL COLLEGE OF VIRGINIA DEPT OF ANATOMY RICHMOND, VA	9	KHANNA, SHIV M. VCU, BOX 2000 PHYSICS DEPT RICHMOND, VA	6	KNISLEY, C. BARRY RANDOLPH MACON COLLEGE DEPT OF BIOLOGY ASHLAND, VA	4
23298		23284-0001		23005	
JOHNSON, MILES F. VA COMMONWEALTH UNIVERSITY BIOLOGY DEPT RICHMOND, VA	4	KIBLER, JOHN J. III MARY BALDWIN COLLEGE DEPT. OF PSYCHOLOGY STAUNTON, VA	10	KO, DAJIM 150 ARKSWRIGHT ROAD RICHMOND, VA	12
23284		22401		23236	
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23284		22405		24061	
JOHNSON, RONALD E. OLD DOMINION UNIVERSITY DEPT. OF OCEANOGRAPHY NORFOLK, VA	15	KIM, MYUNG H. OLD DOMINION UNIVERSITY DEPT OF CHEMISTRY NORFOLK, VA	5	KORNEGAY, ERVIN T. V.P.I. & S.U. DEPT OF ANIMAL SCIENCE BLACKSBURG, VA	1
23508		23508		24061	
JOHNSON, VICKI S. 409 HOLLIDAY DR HAMPTON, VA		KINBROUGH, DANIEL 10300 WALTHAM DR RICHMOND, VA	4	KOSTARAB, MICHAEL V.P.I. & S.U. DEPT OF ENTOMOLOGY BLACKSBURG, VA	4
23666		23233		24061	
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23805		23233		23298	
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23233		23005		23221	
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22030		24450		23508	
JONES, W. GEORGE 1554 CRESTWOOD DR DANVILLE, VA	10	KIRBY, RAYMOND H. 961 LARK AWAY CT VIRGINIA BEACH, VA	10	KUHS, JAMES W. JAMES MADISON UNIVERSITY DEPT. OF PSYCHOLOGY HARRISONBURG, VA	10
24541		23464		22807	
JONES, WILLIAM B. 120 CONVENTION DRIVE VIRGINIA BEACH, VA		KIRCHNER, ROBERT O. 3911 COOPER STREET HUNTSVILLE, AL	7	KUD, ALBERT Y. VA INSTITUTE OF MARINE SCIENCE GLOUCESTER POINT, VA	15
23462		35801		23062	

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LACY, GREGORY D. GEORGE MASON UNIV, CHEM DEPT 9114 CHERRYTREE DRIVE ALEXANDRIA, VA 22309	5	LEVIN, NEAL T. 623 HAMILTON RD SOUTH ORANGE, NJ 07079	5	LUDT, ROBERT E. V.M.I. CHEMISTRY DEPT LEXINGTON, VA 24450	1
LACY, O. W. 1306 HILLCREST RD LANCASTER, PA 17603-2413	9	LEVY, GERALD F. OLD DOMINION UNIVERSITY DEPT OF BIOLOGICAL SCIENCE NORFOLK, VA 23508	1	LUE, LOUIS PING-SION 3003 TINSBERRY DR COLONIAL HEIGHTS, VA 23834	4
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LEHMAN, JAMES D. 1180 SHANANDOAH ST HARRISONBURG, VA 22801	4	LOWRY, RALPH A. UNIV. OF VIRGINIA THORNTON HALL CHARLOTTESVILLE, VA 22901	4	MANDELL, ALAN 200 SNEAD FAIRWAY PORTSMOUTH, VA 23701	4
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MARSHALL, HAROLD G. OLD DOMINION UNIVERSITY DEPT OF BIOLOGY NORFOLK, VA 23518	4	MCMAFFIE, JOHN G. MEDICAL COLLEGE OF VIRGINIA DEPT PHYSIOL BOX 551 MCV STATION RICHMOND, VA 23298	9	MIKULECKY, DONALD C. BOX 551 - MCV STATION RICHMOND, VA 23298	9
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MARTIN, JAMES H. 400B BRENNER BLVD RICHMOND, VA 23228	4	MENAB, F. M. ANNE 606 MCCONKEY ST BLACKSBURG, VA 24060	4	MILICI, ROBERT C. DEPT OF MINES, MINERALS & ENERGY DIV. MIN. RES. - P.O. BOX 3667 CHARLOTTESVILLE, VA 22903	
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MAST, JOSEPH W. EASTERN MENNONITE COLLEGE HARRISONBURG, VA 22801	2	MEACHAM, ROGER H. JR. 480 SPRUCE DRIVE ELTON, PA 19341	9	MILLS, RICHARD R. VCU - BOX 2019 BIOLOGY DEPT RICHMOND, VA 23284	4
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MITCHELL, RICHARD S. UNIVERSITY OF VIRGINIA CLARK HALL CHARLOTTESVILLE, VA 22903	8	MOZINGO, MALTON TIDEWATER RES. & CONT. ED. CENTER HOLLAND STATION SUFFOLK, VA 23437	1	NIEMEYER, A. B. JR. 4324 GREENDELL RD CHESAPEAKE, VA 23321	4
MITCHELL, JOSEPH C. UNIVERSITY OF RICHMOND DEPT OF BIOLOGY RICHMOND, VA 23173	4	MUELLER, PAUL H. HAMPTON-SYDNEY COLLEGE DEPT OF CHEMISTRY HAMPTON-SYDNEY, VA 23943	5	NOLDE, JACK E. 155 W. VALLEY ST ABINGDON, VA 24210	12
MITTMAN, BARBARA ANNE UNIVERSITY OF RICHMOND BIOLOGY DEPARTMENT RICHMOND, VA 23173		MUNSON, ALBERT E. 7412 SANDLEWOOD DR RICHMOND, VA 23235	9	NOREN, RICHARD D. 1905 ARLINGTON ARCH VIRGINIA BEACH, VA 23464	2
MO, LUKE W. V.P.I. AND S.U. PHYSICS DEPT - ROBESON HALL BLACKSBURG, VA 24061	2	MURPHEY, R. S. 2300 CHANCELLOR RD BOW AIR, VIRGINIA 23235	5	NORMAN, JOHN D. VAN OLD DOMINION UNIVERSITY DEPT OF CHEM SCIENCES NORFOLK, VA 23508	5
MOHNEY, REBECCA 1956 THOMSON RD CHARLOTTESVILLE, VA 22903	5	MURRAY, FRANK S. 235 S. PRINCETON CR LYNCHBURG, VA 24503	10	O'BRIEN, JAMES P. B. 1700 COLLEGE CRESCENT VIRGINIA BEACH, VA 23456	10
MORADE, STUART B. 52 SKIPWITH GREEN RICHMOND, VA 23229-3442	5	MUSHRUSH, GEORGE W. GEORGE MASON UNIVERSITY 4400 UNIVERSITY DR, CHEMISTRY DEPT FAIRFAX, VA 22030	5	O'CONNOR, JAMES VINCENT UNIVERSITY OF D.C. 10108 HAYWOOD CIRCLE SILVER SPRING, MARYLAND 20902	8
MOORE, DAVID J. RADFORD UNIVERSITY BOX 5937 RADFORD, VA 24141	4	MYERS, WILLIAM H. UNIVERSITY OF RICHMOND DEPT OF CHEMISTRY RICHMOND, VA 23173	5	O'REAR, CHARLES E. 2754 HILL RD VIENNA, VA 22180	5
MOORE, H. KENT JAMES MADISON UNIVERSITY PHYSICS DEPT HARRISONBURG, VA 22807	2	NAIK, DAYANAND M. OLD DOMINION UNIVERSITY DEPT OF MATH & STAT NORFOLK, VA 23508	12	DATES, KAREN K. GEORGE MASON UNIVERSITY DEPT 810, 4400 UNIVERSITY DR FAIRFAX, VA 22024	9
MOORE, LAURENCE D. V.P.I. & S.U. DEPT. PLANT PATHOLOGY BLACKSBURG, VA 24061	1	NEHER, DEAN R. BRIDGWATER COLLEGE BRIDGWATER, VA 22812	2	OFELI, GEORGE S. 824 ST. CLEMENT RD VA BEACH, VA 23455	2
MOORE, ROBERT J. DEPARTMENT OF CHEMISTRY VCU BOX 2006 RICHMOND, VA 23284	5	NEVES, RICHARD J. V.P.I. AND S.U. FISHERIES AND WILDLIFE BLACKSBURG, VA 24061	15	OGBONMAYA, CHUKS A. P.O. BOX 957 BLUESTONE GAP, VA 24219	1
MOOZ, ELIZABETH D. PHILIP MORRIS U.S.A. - RES. CTR. P.O. BOX 26583 RICHMOND, VA 23261	9	NEWTON, ROBERTA A. SCHOOL OF PHYSICAL THERAPY BOX 224-MED. COLLEGE OF VIRGINIA RICHMOND, VA 23298	4	OGBURN, THOMAS J. III 14 ALBERMARLE AVE RICHMOND, VA 23226	2
MORGAN, JOHN P. OLD DOMINION UNIVERSITY DEPT OF MATH AND STATISTICS NORFOLK, VA 23508	12	NEWTON, SCOTT H. VIRGINIA STATE UNIVERSITY BOX 5 PETERSBURG, VA 23803	1	OGLE, DOUGLAS W. VA HIGHLANDS COMMUNITY COLLEGE P.O. BOX 828 ABINGDON, VA 24210	4
MORRDN, LEONARD 1217 HILLSIDE AVE RICHMOND, VA 23229-5919	14	NIEHAUS, JUDY H. RADFORD UNIVERSITY DEPT OF BIOLOGY RADFORD, VA 24141		OGLIARUSO, M. A. V.P.I. & S.U. 126 WILLIAMS HALL BLACKSBURG, VA 24061	5
MORSE, LARRY E. THE NATURE CONSERVANCY 1800 N. KENT ST ARLINGTON, VA 22209	14	NIELSEN, ANNE M. BLUERIDGE COMM COLLEGE 45 EAST GROTIAN STREET HARRISONBURG, VA 22801		OLSON, LEE C. CHRISTOPHER NEWPORT COLLEGE DEPT OF BIOLOGY NEWPORT NEWS, VA 23606	14
MORTON, HAROLD S. JR. 3500 MONACAN DR CHARLOTTESVILLE, VA 22901	2	NIELSEN, LARRY VPI & SU DEPT OF FISH & WILDLIFE BLACKSBURG, VA 24061	15	ORCUTT, DAVID M. V.P.I. & S.U. DEPT PLANT PATH & WEED SCIENCE BLACKSBURG, VA 24061	14
MOSE, DOUGLAS C. 4700 GROVES LANE FAIRFAX, VA 22030-4411	8	NIELSEN, PETER T. JAMES MADISON UNIVERSITY BIOLOGY DEPT HARRISONBURG, VA 22807	4	ORTH, DONALD V.P.I. & S.U. FISH AND WILDLIFE BLACKSBURG, VA 24061	15

ORWOLL, ROBERT A. COLLEGE OF WILLIAM AND MARY DEPT. OF CHEMISTRY WILLIAMSBURG, VA 23185	5	PERHAM, JAMES E. RANDOLPH-MACON WOMAN'S COLLEGE DEPT. OF BIOLOGY LYNCHBURG, VA 24503	4	PITTMAN, ROLAND R. DEPT OF PHYSIOLOGY BOX 551 - MCV RICHMOND, VA 23298	9
OSCAR, KENNETH J. 4031 SHERBON LANE SPRINGFIELD, VA 22152	2	PETERS, DANIEL J. 501-B BRIDGE CROSSING YORKTOWN, VA 23692	4	PLEBAN, PATRICIA 1177 CLYDESDALE LANE VIRGINIA BEACH, VA 23464	5
OSGOOD, CHRIS OLD DOMINION UNIVERSITY DEPT OF BIOLOGICAL SCIENCES NORFOLK, VA 23508	4	PETERS, PHILIP B. 606 JACKSON AVE LEXINGTON, VA 24450	2	PLETTA, DAN H. V.P.I. AND S.U. 1414 HIGHLAND CIRCLE, SE BLACKSBURG, VA 24060	
OSTRANDER, LAURA R. OLD DONATION GIFTED CENTER 1008 FERRY PLANTATION ROAD VIRGINIA BEACH, VA 23462		PETERSON, DORM JAMES MADISON UNIVERSITY PHYSICS DEPT HARRISONBURG, VA 22807	2	PLEVA, MICHAEL A. WASHINGTON AND LEE UNIVERSITY DEPT OF CHEMISTRY LEXINGTON, VA 24450	5
OTTENBRITE, RAPHAEL M. 901 W. FRANKLIN ST RICHMOND, VA 23220	5	PETTUS, ALVIN M. JAMES MADISON UNIVERSITY EDUCATIONAL RESOURCES DEPT HARRISONBURG, VA 22807	11	POLAND, JAMES L. MEDICAL COLLEGE OF VIRGINIA DEPT OF PHYSIOLOGY RICHMOND, VA 23298	9
OWENS, CHARLES H. RT. 4 BOX 158 BRISTOL, TN 37620	4	PETTUS, WILLIAM G. RT. 2, BOX 202 MONROE, VA 24574	2	PORTLOCK, WILLIAM S. RT. 1, BOX 107 BOWLING GREEN, VA 22427	4
OWERS, MOEL D. DEPT OF ANATOMY-BOX 709 MCV 1200 E. BROAD ST RICHMOND, VA 23298		PFEIFFER, DOUGLAS G. SHENANDOAH VALLEY RES. STATION STEELES TAVERN, VA 24476	4	POTTER, LAWRENCE M. 1407 HILLCREST DR BLACKSBURG, VA 24060	5
PADGETT, DORAN W. 3801 N. 36TH RD ARLINGTON, VA 22207	2	PHARR, DANIEL YORK VIRGINIA MILITARY INSTITUTE CHEMISTRY DEPT LEXINGTON, VA 24450	5	POWELL, W. ALLAN RFD 395 H DELTAVILLE, VA 23043	5
PAGELS, JOHN F. VA COMMONWEALTH UNIVERSITY DEPT. OF BIOL. ACAD. CENTER RICHMOND, VA 23220	4	PHIPPS, RICHARD L. U.S. GEOLOGICAL SURVEY RESTON, VA 22092	8	PRAGER, MICHAEL H. OLD DOMINION UNIVERSITY OCEANOGRAPHY DEPARTMENT NORFOLK, VA 23529-0276	15
PAINTER, HARRY F. 8324 THE MIDWAY ANNANDALE, VA 22003		PIENKOWSKI, ROBERT L. V.P.I. & S.U. DEPT OF ENTOMOLOGY BLACKSBURG, VA 24061	1	RAMINEZ, DONALD E. DEPT. OF MATH - UNIV. OF VIRGINIA MATH - ASTRO. BLDG - CABELL DRIVE CHARLOTTESVILLE, VA 22903	
PALISANO, JOHN R. ENDRY & HENRY COLLEGE DEPT OF BIOLOGY ENDRY, VA 24327	4	PIERPONT, P. KENNETH RETIRED NASA, LRC 204 CEDER POINT CRES. YORKTOWN, VA 23692		RAMSEY, GWYN W. 1218 CHARLTON RD LYNCHBURG, VA 24501	14
PARKER, BRUCE C. DERRING HALL, V.P.I. DEPT OF BIOLOGY BLACKSBURG, VA 24061	3	PINKSTON, MARGARET 16 CHURCH STREET STAUNTON, VA 24401	4	RANGAPPA, M. VIRGINIA STATE UNIVERSITY P.O. BOX 453 PETERSBURG, VA 23803	1
PARKINSON, THOMAS F. 1414 HILLCREST DR BLACKSBURG, VA 24060	7	PINSCHMIDT, MARY W. 8 NELSON ST FREDERICKSBURG, VA 22405	9	RATCHFORD, J. THOMAS 8804 FIRCREST PLACE ALEXANDRIA, VA 22308	2
PATRICK, JAMES B. MARY BALDWIN COLLEGE DEPT OF CHEMISTRY STAUNTON, VA 24401	5	PINSCHMIDT, WILLIAM C. JR. 8 NELSON ST FREDERICKSBURG, VA 22405	4	REEVES, JOHN H. JR. V.M.I. DEPT OF BIOLOGY LEXINGTON, VA 24450	4
PEACHEE, CHARLES 9961 OLDFIELD DR RICHMOND, VA 23325	10	PITT, LOREN D. DEPT OF MATH, MATH-ASTRO BLDG UNIVERSITY OF VIRGINIA CHARLOTTESVILLE, VA 22903	2	REID, J. DOUGLAS 5701 WILLIAMSBURG LANDING DR WILLIAMSBURG, VA 23185-3780	3
PENBERTHY, ANN R. COLONY PLAZA 13354 MIDLOTHIAN TURNPIKE MIDLOTHIAN, VA 23113-4210	10	PITTAS, PEGGY 719 SHERMAN DRIVE LYNCHBURG, VA 24502	10	REIFSWIDER, KENNETH L. 5 WOODLAND HILLS DR BLACKSBURG, VA 24060	6



REINDERS, THOMAS P. BOX 581 - MCV STATION RICHMOND, VA 23298	9	ROANE, CURTIS W. V.P.I. DEPT PLANT PATH, PHYSIO, WEED SCI BLACKSBURG, VA 24061	1	RUDIN, JOSEPH W. JAMES MADISON UNIVERSITY PHYSICS DEPT HARRISONBURG, VA 22807	2
RENEAU, R. B. JR. 904 ELIZABETH DR BLACKSBURG, VA 24060	1	ROANE, MARTHA K. V.P.I. & S.U. DEPT PLANT PATHOLOGY & PHYS BLACKSBURG, VA 24061	14	RUNDBERG, ERIC S. JR. 1313 WILDERNESS RD RICHMOND, VA 23231	5
RENFROE, MICHAEL H. JAMES MADISON UNIVERSITY BIOLOGY DEPT HARRISONBURG, VA 22807	14	ROBERTS, JAMES E. SR. V.P.I. & S.U. 215 PRICE HALL BLACKSBURG, VA 24061	1	RUSSNOW, ARTHUR L. 11524 JEFFERSON AVE NEWPORT NEWS, VA 23601	8
REPICI, DOMINIC J. 4105 WINSTRELL LANE FAIRFAX, VA 22033	2	ROCKWOOD, LARRY L. GEORGE MASON UNIVERSITY DEPT OF BIOLOGY FAIRFAX, VA 22030	4	SAIEED, ALFRED E. P.O. BOX 64 FAIRFAX, VA 22030	5
REYNOLDS, MARION R. JR. V.P.I. & S.U. DEPT OF STATISTICS BLACKSBURG, VA 24061	12	RODE, RICHARD A. ABBOTT LABORATORIES MONCLINAL STATISTICS ABBOTT PARK, IL 60064		SANTOS, J. G. DOS 2 GLENBROOK CIRCLE WEST RICHMOND, VA 23229	9
REZBA, RICHARD J. V.C.U. BOX 2020 SCHOOL OF EDUCATION RICHMOND, VA 23284-2020	11	RODIG, OSCAR R. UNIVERSITY OF VIRGINIA DEPT OF CHEMISTRY CHARLOTTESVILLE, VA 22903	5	SANZONE, GEORGE 3400-L FOXRIDGE APTS BLACKSBURG, VA 24060	2
RIBAND, ROBERT J. MECHANICAL ENGINEERING, UVA 310 THORNTON HALL, MCCORMICK RD CHARLOTTESVILLE, VA 22901		RODRIGUEZ, GIL E. M.C.V. P. O. BOX 225 RICHMOND, VA 23298		SAUDER, WILLIAM C. V.M.I. DEPT. OF PHYSICS LEXINGTON, VA 24450	2
RICHARD, ALFRED J. M.C.V. SCHOOL OF PHARMACY RICHMOND, VA 23219	9	ROONEY, HUGH 2904 CRAIGWOOD CIRCLE MECHANICSVILLE, VA 23111	14	SAVITZKY, ALAN H. OLD DOMINION UNIVERSITY DEPT OF BIOLOGICAL SCIENCES NORFOLK, VA 23529-0266	4
RICHARDS, ELIAS III MRS. 905 OLD TRENTS FERRY RD LYNCHBURG, VA 24503	4	ROOP, ROY MARTY II 2300 J FOXRIDGE APTS BLACKSBURG, VA 24060		SCANLON, PATRICK F. V.P.I. AND S.U. DEPT. OF FISH. AND WILDLIFE SCI. BLACKSBURG, VA 24061	
RICHARDSON, JOHN H. OLD DOMINION UNIVERSITY BIOLOGY DEPT NORFOLK, VA 23508	9	ROSE, DALE E. 729 BEACH RD HAMPTON, VA 23664	5	SCHATZ, PAUL M. U. OF VA., DEPT. OF CHEM. UNIVERSITY STATION CHARLOTTESVILLE, VA 22903	5
RICKETT, FREDERIC L. 12521 EASY STREET CHESTER, VA 23831	5	ROSE, OLLIE J. 260 MALDEN LANE NEWPORT NEWS, VA 23602	13	SCHLEMMER, KARL A. 1332 LAKEVIEW DRIVE VIRGINIA BEACH, VA 23455	9
RIETHMILLER, STEVEN V.M.I. CHEMISTRY DEPT LEXINGTON, VA 24450	5	ROSE, ROBERT K. OLD DOMINION UNIVERSITY DEPT. OF BIOLOGICAL SCIENCE NORFOLK, VA 23508	4	SCHOOK, LAWRENCE B. 605 HAMILTON DRIVE CHAMPAIGN, IL 61820-6809	
RITT, PAUL E. 36 SYLVAN LAKE WESTON, MA 02193	5	ROSENTHAL, MIRIAM D. EASTERN VA MEDICAL SCHOOL DEPT. OF BIOCHEMISTRY - BOX 1980 NORFOLK, VA 23501	9	SCHREIBER, HENRY D. V.M.I. DEPT OF CHEMISTRY LEXINGTON, VA 24450	5
RITTER, ALFRED L. V.P.I. & S.U. DEPT OF PHYSICS BLACKSBURG, VA 24061	2	ROTHBERG, SIMON MEDICAL COLLEGE OF VA - V.C.U. BOX 127 RICHMOND, VA 23298	9	SCHREINER, SERGE 2304-SA HICKORY CREEK CIRCLE RICHMOND, VA 23229	5
RITTER, ROGER C. 117 CHESTNUT RIDGE ROAD CHARLOTTESVILLE, VA 22901	2	ROWE, H. ALAN NORFOLK STATE UNIVERSITY DEPT. OF CHEMISTRY NORFOLK, VA 23504		SCHUG, JOHN C. RFD. 1, BOX 431-A BLACKSBURG, VA 24060	5
RIVERS, GUY LYNCHBURG COLLEGE DEPT. OF BIOLOGY LYNCHBURG, VA 24501	15	RUCKART, ROBERT T. RT. 1, BOX 162-C PROVIDENCE FORGE, VA 23140	4	SCHULMAN, ROBERT S. V.P.I. AND S.U. DEPT OF STATISTICS BLACKSBURG, VA 24061	12

SCHULTZ, PETER B. 1444 DIAMOND SPRINGS ROAD VIRGINIA BEACH, VA 23455	1	SHAYER, ROBERT G. VERSER INC. 6621 ELECTRONIC DR SPRINGFIELD, VA 22151	6	SITZ, THOMAS O. V.P.I. & S.U. DEPT OF BIOCHEMISTRY BLACKSBURG, VA 24061	5
SCOTT, FREDERIC R. 115 KENNEDDALE LAKE RICHMOND, VA 23226	4	SHEAR, NATHANIEL 1401 BLAIR MILL RD. S. SILVER SPRING, MD 20910	2	SJDERDSMA, TED WASHINGTON AND LEE UNIVERSITY DEPT OF COMPUTER SCIENCE LEXINGTON, VA 24450	2
SCOTT, JOHN E. JR. UNIVERSITY OF VIRGINIA PAVILION IV-EAST LAWN CHARLOTTESVILLE, VA 22903-3205	13	SHEAVLY, SEBA B. 3124 VERNE AVE PORTSMOUTH, VA 23703	14	SKOG, JUDITH C. GEORGE MASON UNIVERSITY 440 - BIOLOGY FAIRFAX, VA 22030	14
SCRIVENER, J. G. 12913 SILVER CREST CHESTER, VA 23831	5	SHEDD, DOUGLAS H. RANDOLPH MACON WOMAN'S COLLEGE BOX 475 - DEPT OF BIOLOGY LYNCHBURG, VA 24503	4	SMILES, REBORAH L. 2827 HILLIARD RD APT H RICHMOND, VA 23228	5
SCULLY, FRANK E. JR OLD DOMINION UNIVERSITY DEPT OF CHEMICAL SCIENCES NORFOLK, VA 23508		SHELTON, KEITH R. MCV-VCU BOX 614, COLLEGE STATION RICHMOND, VA 23298-0614	9	SHELTZER, JAMES S. M.D. MEDICAL COLLEGE OF VA BOX 34, MCV STATION RICHMOND, VA 23298	9
SEARS, C.E. 604 AIRPORT RD BLACKSBURG, VA 24060	8	SHERALD, ALLEN F. 9451 LEE HIGHWAY #1209 FAIRFAX, VA 22031	4	SMITH, B. D. P.O. BOX 1026 DAHLGREN, VA 22448	5
SEIBEL, HUGO R. MEDICAL COLLEGE OF VA DEPT. OF ANATOMY RICHMOND, VA 23219	9	SHERWOOD, W. CULLEN JAMES MADISON UNIV. DEPT. OF GEOLOGY - MILLER HALL HARRISONBURG, VA 22807	8	SMITH, DAVID F. VIRGINIA TECH. BIOCHEM & NUTRITION BLDG BLACKSBURG, VA 24061	9
SEIDENBERG, ARTHUR J. VA COMMONWEALTH UNIVERSITY DEPT OF BIOLOGY RICHMOND, VA 23284	4	SHERWOOD, WILLIAM A. LYNCHBURG COLLEGE BIOLOGY DEPT LYNCHBURG, VA 24501	14	SMITH, ELSE V. P. VIRGINIA COMMONWEALTH UNIVERSITY 900 PARK AVE, HIBBS BLDG, ROOM 305 RICHMOND, VA 23284-2019	2
SELIM, RAOUF 510 LOGAN PLACE, #41 NEWPORT NEWS, VA 23601	6	SHILLINGTON, JAMES BOX 557 LEXINGTON, VA 24450	5	SMITH, ENNA B. VIRGINIA STATE UNIVERSITY 3400 NORTH STREET ETTRICK, VA 23803	
SELLERS, CLETE M. JAMES MADISON UNIVERSITY DEPT. OF BIOLOGY HARRISONBURG, VA 22807	4	SHOLLEY, MILTON M. BOX 709 - MCV STATION RICHMOND, VA 23298	9	SMITH, J. DOYLE VA COMMONWEALTH UNIVERSITY SCHOOL OF PHARMACY RICHMOND, VA 23298	5
SEN, DILIP K. VIRGINIA STATE UNIVERSITY BIOMEDICAL RESEARCH, BOX 6 PETERSBURG, VA 23803	4	SHOULDERS, JOHN F. 509 MONTE VISTA DR. SW BLACKSBURG, VA 24060	1	SMITH, JOHN C. 400 KINGSDALE ROAD HOLLAND STATION SUFFOLK, VA 23437	1
SETTLE, FRANK A. VIRGINIA MILITARY INSTITUTE DEPT OF CHERISTRY LEXINGTON, VA 24450	5	SIEGEL, PAUL B. V.P.I. AND S.U. DEPT. OF POULTRY SCIENCE BLACKSBURG, VA 24061		SNEDEH, ALBERT T. VA COMMONWEALTH UNIV DEPT OF CHERISTRY RICHMOND, VA 23284	5
SHADOMY, H. JEAN MEDICAL COLLEGE OF VA BOX 847 RICHMOND, VA 23298	3	SILVER, BEVERLY P. 1550 VALE CIRCLE HARRISONBURG, VA 22801	4	SOINE, PHYLLIS J. 2406 RIVERSIDE DR RICHMOND, VA 23225	5
SHADOMY, SMITH MEDICAL COLLEGE OF VA BOX 38 RICHMOND, VA 23298	3	SIMMONS, GEORGE M. V.P.I. AND S.U. DEERING HALL BLACKSBURG, VA 24060	4	SOINE, WILLIAM HENRY SCH. OF PHARMACY - MCV - VCU P. O. BOX 581 - MCV STATION RICHMOND, VA 23298	9
SHANMOLTZ, VERNON O. V.P.I. AND S.U. AGRICULTURAL ENGR. BLACKSBURG, VA 24061	1	SIMPSON, MARGARET SWEET BRIAR COLLEGE BOX 26 SWEETBRIAR, VA 24595	4	SOJKA, NICKLAS J. UVA MED. SCHOOL-JORDAN BLDG 1300 JEFFERSON PARK AVE CHARLOTTESVILLE, VA 22908	9
SHARPE, BETTY D. 32 HUGENOT ROAD NEWPORT NEWS, VA 23606	11	SIPE, HERBERT J. JR. HAMPUEN-SYDNEY COLLEGE DEPT OF CHERISTRY HAMPUEN-SYDNEY, VA 23943	5	SOKOLOWSKI, STEVEN W. 1267-A W. 27TH ST NORFOLK, VA 23508	3

SPERMAN, M. LEROY NASA, LANGLEY RESEARCH CENTER N.S. 412 HAMPTON, VA 23665	13	STEPHENSON, STEVEN L. 1115 MORNINGSTAR LANE FAIRMONT, WV 26654	14	TALLEY, CLAUDE P. 3441 NORTHVIEW STREET RICHMOND, VA 23225	5
SPENCER, EDGAR W. WASHINGTON AND LEE UNIV GEOLOGY DEPT LEXINGTON, VA 24450	8	STEVENS, CHARLES E. 615 PRESTON PLACE CHARLOTTESVILLE, VA 22903	4	TARANTINO, LAURA M. P.O. BOX 1980 NORFOLK, VA 23501	9
SPENCER, GORDON L. U.S.A. FSTC 220 - 7TH ST. N.E. CHARLOTTESVILLE, VA 22901		STEWART, JENNIFER K. VIRGINIA COMMONWEALTH UNIVERSITY DEPT OF BIOLOGY, 816 PARK AVE RICHMOND, VA 23284	9	TAYLOR, CHAMLEY ROY JR. 2715 FENHOLLOWAY DRIVE MECHANICSVILLE, VA 23111	5
SPENCER, RANDALL S. OLD DOMINION UNIVERSITY GEOLOGY DEPT NORFOLK, VA 23508	8	STEWART, KENT K. VPI & SU DEPT BIOCHEMISTRY & NUTRITION BLACKSBURG, VA 24061	5	TEATES, THOMAS G. RT. 84, BOX 551 CHRISTIANSBURG, VA 24073	11
SPENCER, TURNER M. THOMAS NELSON COMMUNITY COLLEGE BIOLOGY DEPT HAMPTON, VA 23366	11	STEWART, ROBERTA A. BOX 9685 HOLLINS COLLEGE, VA 24020	5	TELONIS, D. P. V.P.I. & S.U. ENG. SCIENCE & MECH. BLACKSBURG, VA 24061	13
SPIETH, ALICE H. 221 BENT TREE TRAIL BURLESON, TX 76028	4	STIPES, R. JAY V.P.I. DEPT. OF PATHOLOGY AND PHYSIOLOGY BLACKSBURG, VA 24061	14	TERMAN, C. RICHARD COLLEGE OF WILLIAM AND MARY BIOLOGY DEPT WILLIAMSBURG, VA 23185	4
SPRESSER, DIANE JAMES MADISON UNIV. MATH AND COMP. SCIENCE DEPT. HARRISONBURG, VA 22807	2	STOUGHTON, JOHN W. 1109 GERAMUN CRESCENT VIRGINIA BEACH, VA 23456		TURNER, JAMES VA COMMONWEALTH UNIVERSITY CHEMISTRY DEPT RICHMOND, VA 23284	5
SQUIRES, ARTHUR M. 2710 QUINCY COURT BLACKSBURG, VA 24060	7	STOUT, ERNEST R. VPI & SU DEPARTMENT OF BIOLOGY BLACKSBURG, VA 24061	14	TERWILLIGER, KAREN A. VIRGINIA GAME COMMISSION BROAD ST., BOX 11104 RICHMOND, VA 23230	
STABLER, JEANNE J. TIDEMAR COMMUNITY COLLEGE FREDERICK CAMPUS PORTSMOUTH, VA 23703	4	STROMACH, CAREY E. 2241 BUCKNER STREET PETERSBURG, VA 23805	2	TEW, JOHN G. MEDICAL COLLEGE OF VIRGINIA P.O. BOX 678, MCY STATION RICHMOND, VA 23298	
STALEY, H. W. IV BOX 25 WOODBERRY FOREST, VA 22989	11	STRONG, SUSAN M. B. RT. 3, BOX 41 FERRUM, VA 24088	9	THOMPSON, ERTL 308 MONTEBELLO CIRCLE CHARLOTTESVILLE, VA 22903	5
STALICK, WAYNE M. GEORGE MASON UNIVERSITY CHEMISTRY DEPT FAIRFAX, VA 22030	5	STUMP, B. L. 2811 LONDON PARK DR HIDLOTHIAN, VA 23113	5	THOMPSON, FRANK M. P.O. BOX 26609 RICHMOND, VA 23261-6609	
STANDUBIS, VASSILIS ARGONNE NAL. LABS 9700 S. CASS. AVE - ER - 203 ARGONNE, IL 60439	5	SU, SYANG YANG V.C.U. - DEPT. OF CHEMISTRY 1001 WEST MAIN STREET RICHMOND, VA 23284	5	THOMPSON, JESSE C. JR. ROANOKE COLLEGE DEPT OF BIOLOGY SALEM, VA 24153	4
STANLEY, MELISSA 4224 SIELEBURN ROAD FAIRFAX, VA 22030	4	SWANSON, ROBERT JAMES OLD DOMINION UNIVERSITY DEPT. OF BIOLOGICAL SCIENCES NORFOLK, VA 23508-8503	4	TIGNOR, KEITH R. V.P.I. AND S.U. DEPT. OF ENTOMOLOGY BLACKSBURG, VA 24061	
STARLING, T. M. V.P.I. & S.U. AGRONOMY DEPT BLACKSBURG, VA 24061	1	SWEITZER, EDWARD M. 515 PLYMOUTH RD. APT 1-3 PLYMOUTH MTG, PA 19462	4	TILL, MARGARET L. OLD DOMINION UNIVERSITY DEPT OF BIOLOGICAL SCIENCES NORFOLK, VA 23508	9
STARNER, DAVID E. P.O. BOX 448 ORANGE, VA 22960	1	SWIFT, DONALD J. P. OLD DOMINION UNIVERSITY DEPT OCEANOGRAPHY NORFOLK, VA 23508	8	TIMKO, MICHAEL P. UNIVERSITY OF VIRGINIA DEPT OF BIOLOGY CHARLOTTESVILLE, VA 22901	14
STEEHLER, JACK UNIVERSITY OF VIRGINIA DEPT OF CHEMISTRY CHARLOTTESVILLE, VA 22901	5	SZNYTER JR., EDWARD W. P.O. BOX 5736 VIRGINIA BEACH, VA 23455-0736	11	TINNELL, WAYNE H. LONGWOOD COLLEGE DEPT OF NATURAL SCIENCE FARMVILLE, VA 23701	3



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WATERS, MARIE RADFORD COLLEGE STATION BOX 5761 RADFORD, VA 24141	10	TIWARI, SURENDRA M. OLD DOMINION UNIVERSITY MECHANICAL ENGINEERING DEPT NORFOLK, VA 23508	13	VALLARINO, LIDIA M. CHEMISTRY DEPT, VCU 1015 N. MAIN ST RICHMOND, VA 23284	5	
WATTS, C. F. RADFORD UNIVERSITY GEOLOGY DEPT, BOX 5901 RADFORD, VA 24142		TOBIAS, JOSEPH J. 2200 BRIMMYNINE DR CHARLOTTESVILLE, VA 22901	2	VAN BRUNT, MICHAEL R. 1336 GUNNELL COURT MCLEAM, VA 22102		
WEANO, BARRON L. 8477 STONEWALL RD MANASSAS, VA 22110	15	TOPHAN, RICHARD W. 11821 YOUNG MANOR DR MIDDLEBURY, VA 23113	5	VAN ENGEL, WILLARD A. VA. INSTITUTE OF MARINE SCIENCE GLOUCESTER POINT, VA 23062	4	
WEANO, DIANA C. 8908 FORT ORIVE MANASSAS, VA 22110	4	TOPICH, JOSEPH VA COMMONWEALTH UNIVERSITY DEPT OF CHEMISTRY RICHMOND, VA 23284	5	VAN KREY, HARRY P. V.P.I. AND S.U. - POULTRY SCIENCE 2270 ANIMAL SCIENCE BLDG BLACKSBURG, VA 24061	1	
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WEBB, GEORGE R. 12 BRIAR PATCH PLACE NEWPORT NEWS, VA 23606	2	TRELAWNY, GILBERT S. JAMES MADISON UNIVERSITY BOX 606 HARRISONBURG, VA 22807	3	VAUGHAN, DAVID H. V.P.I. AND S.U. 311 SEITZ AGR. ENGR. BLACKSBURG, VA 24061	8	
WEBB, KENNETH L. SCHOOL OF MARINE SCIENCE COLLEGE OF WILLIAM AND MARY GLOUCESTER POINT, VA 23062	4	TRICE, ASHTON O. MARY BALOWIN COLLEGE DEPT. OF PSYCHOLOGY STAUNTON, VA 24401	10	VAUGHAN, JERE J. 12131 BRAMMELIGH PLACE FAIRFAX STATION, VA 22039		
WEILAND, ELIZABETH M. 2004 BURKS STREET PETERSBURG, VA 23805	4	TRDUT, W. E. 111 35 TOWANA ROAD RICHMOND, VA 23226	4	VENABLE, DEMETRIUS O. HAMPTON INSTITUTE BOX 6465 HAMPTON, VA 23668	2	
WEISS, T. EDWARD JR. CHRISTOPHER NEWPORT COLLEGE DEPT OF BIOLOGY NEWPORT NEWS, VA 23606	14	TROWER, W. PETER PHYSICS/ VIRGINIA TECH BLACKSBURG, VA 24061	2	VDIGE, WILLIAM H. JAMES MADISON UNIVERSITY DEPT OF CHEMISTRY HARRISONBURG, VA 22801	5	
WELCH, CHRISTOPHER S. ROUTE 3, BOX 1076 GLOUCESTER, VA 23061	2	TUCKER, JAMES R. II 2800 HAWK DRIVE RICHMOND, VA 23235-3140	11	WAKEHAN, HELMUT R. 8905 MORWICK RD RICHMOND, VA 23229	5	
WELSTEAD, WILLIAM J. 8306 BROOKFIELD ROAD RICHMOND, VA 23227	5	TURNER, E. C. JR. V.P.I. AND S.U. DEPT. OF ENTOMOLOGY BLACKSBURG, VA 24061	1	WALKER, RICHARD D. V.P.I. AND S.U. DEPT. OF CIVIL ENGR. BLACKSBURG, VA 24061	7	
WEST, DAVID A. V.P.I. AND S.U. DEPT. OF BIOLOGY BLACKSBURG, VA 24061	4	TURNER, GAIL C. 2608 COTTAGE COVE DR RICHMOND, VA 23233		WARD, JOHN W. A.H. ROBINS CO., INC. 1407 CUMMINGS DR RICHMOND, VA 23220	5	
WETMORE, STANLEY I. JR. VA. MILITARY INSTITUTE CHEMISTRY DEPT LEESBURG, VA 24450	5	UPCHURCH, BILLY T. CONSULTING ANALYTICAL CHEMIST 1213 BLUEBIRD AVE VIRGINIA BEACH, VA 23451	5	WARE, DONNA EGGERS COLLEGE OF WILLIAM AND MARY BIOLOGY DEPT WILLIAMSBURG, VA 23185	14	
WHISONANT, ROBERT C. RADFORD COLLEGE DEPT OF GEOLOGY RADFORD, VA 24141	8	URAS, I. T. HAMPTON UNIVERSITY DEPT OF CHEMISTRY HAMPTON, VA 23668	5	WARE, STEWART A. COLLEGE OF WILLIAM AND MARY BIOLOGY DEPT WILLIAMSBURG, VA 23185	14	
WHITE, LARRY H. HARRISONBURG HIGH SCHOOL DEPT OF CHEMISTRY HARRISONBURG, VA 22801	5	WANALA, LINDA 138 NINA LANE WILLIAMSBURG, VA 23185		WARMNER, JUNIUS E. VA INST. OF MARINE SCIENCE THE COLLEGE OF WILLIAM AND MARY GLOUCESTER POINT, VA 23062		

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WILLIS, LLOYD L. PIEDMONT VA. COMMUNITY COLLEGE RT. 6, BOX 11-A CHARLOTTESVILLE, VA 22901	14	WHITEHURST, MARY CAMDACE 813 GATES AVE. #2 NORFOLK, VA 23517-1637	5	WRIGHT, EUGENE M. BOX 450 - MEDICAL CENTER 1300 JEFFERSON PARK AVE CHARLOTTESVILLE, VA 22908	9
WILLS, WIRT V.P.I. AND S.U. DEPT OF PLANT PATHOLOGY BLACKSBURG, VA 24061	1	WHITNEY, DONALD A. HAMPTON INSTITUTE PHYSICS ENGINEERING DEPT HAMPTON, VA 23668	2	WRIGHT, KATHRYN 10505 MOUNTAIN BROOK CT RICHMOND, VA 23233	9
WILSDORF, H. G. F. UNIV. OF VA. - THORNTON HALL DEPT. OF MATERIALS SCIENCE CHARLOTTESVILLE, VA 22903	7	WHITNEY, GEORGE S. WASHINGTON AND LEE UNIVERSITY DEPT OF CHEMISTRY LEXINGTON, VA 24450	5	WRIGHT, ROBERT A. S. CENTRAL VA BIOL. RESEARCH CONS. 5204 RIVERSIDE DRIVE RICHMOND, VA 23225	14
WILSON, ERNEST VA STATE COLLEGE BOX 64 PETERSBURG, VA 23803	14	WHITTECAR, G. RICHARD OLD DOMINION UNIVERSITY GEOPHYSICAL SCIENCES NORFOLK, VA 23508	8	WRIGHT, THEODORE R. F. UNIV OF VA, BIOLOGY DEPT UNIVERSITY STATION CHARLOTTESVILLE, VA 22903	4
WILSON, R. T. V.M.I. DEPT OF CHEMISTRY LEXINGTON, VA 24450	5	WHYBURN, LUCILLE E. 133 BOLLINGWOOD ROAD CHARLOTTESVILLE, VA 22903	2	WYATT, KATHRYN BENTON 301 MAGNOLIA DRIVE DANVILLE, VA 22454	10
WILTSHIRE, JAMES W. JR MRS 201 WOODLAND AVE LYNCHBURG, VA 24503	4	WICHNER, ROBERT C. 2569 MELWOOD RD NARAKIN-SABOT, VA 23103	15	YAMNI, JOHN 5702 OAK KNOLL ROAD MIDLOTHIAN, VA 23113-8907	9
WINGFIELD, E. BURNELL V.M.I. BIOLOGY DEPT LEXINGTON, VA 24450	4	WICKHAM, JAMES E. JR. 109 BEVERLY RD ASHLAND, VA 23005	5	YOUNG, EDNA LOVING 125 ROBERTSON AVE DANVILLE, VA 24541	4
WINTER, ROLF G. COLLEGE OF WILLIAM AND MARY PHYSICS DEPT WILLIAMSBURG, VA 23185	2	WIEBOLDT, THOMAS F. RT. 4, BOX 526 CHRISTIANSBURG, VA 24073	14	YOUNG, PHILIP R. 112 LEE AVE POWERSBORO, VA 23362	5
WISNER, LAWRENCE A. MARY WASHINGTON COLLEGE DEPT OF CHEMISTRY FREDERICKSBURG, VA 22402	5	WIELAND, WERNER MARY WASHINGTON COLLEGE DEPT OF BIOLOGICAL SCIENCES FREDERICKSBURG, VA 22401	4	YOUNG, RODERICK W. 702 AIRPORT RD BLACKSBURG, VA 24060	1
WOHL, PHILIP R. OLD DOMINION UNIVERSITY DEPT OF MATH & STAT NORFOLK, VA 23508	2	WIGGLESWORTH, WAYWOOD A. HENRICO CITY PUBLIC UTILITIES 22 N. SHEPARD STREET RICHMOND, VA 23221		YOSTEN, ALLEN A. V.P.I. AND S.U. BIOLOGY DEPT BLACKSBURG, VA 24061	3
WOLFE, LUKE G. BOX 539 - MCY STATION RICHMOND, VA 23298		WIGHTMAN, JAMES P. V.P.I. AND S.U. DEPT OF CHEMISTRY BLACKSBURG, VA 24061	5	ZAPOTOCZNY, JOSEPH E. RT. 2, BOX 16 WAYNESBORO, VA 22980	
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WOOLCOTT, WILLIAM S. UNIV. OF RICHMOND BOX 248 RICHMOND VA 23173	4	WILLIAMS, R. L. OLD DOMINION UNIVERSITY DEPT. OF CHEMISTRY NORFOLK, VA 23508	5		

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ALLEN, SARAH T. 130 BURNETT DR SPARTANBURG, SC 29302	9	BRENNAN, TIMOTHY V.P.I. & S.U. DEPT PLPP BLACKSBURG, VA 24060	1	CHRISTOS, THOMAS OLD DOMINION UNIVERSITY DEPT OF CHEMICAL SCIENCES NORFOLK, VA 23508	5
ASKEN, DAVID V.P.I. & S.U. BIOLOGY DEPT BLACKSBURG, VA 24061	3	BRICE, JENNIFER C. 2526 DRUM CREEK ROAD CHESAPEAKE, VA 23321		CLARKE, PETER 1005 WILAKA LAKE RICHMOND, VA 23227	
AUERBACH, PARIS LYN 1516 WEST AVE APT I RICHMOND, VA 23220	9	BROWN, MORRIS E. 5611 DANVERS ROAD PORTSMOUTH, VA 23703	9	COFFELT, MARK A. HAMPTON ROADS AGR. EXP. STN. 1444 DIAMOND SPRINGS RD VIRGINIA BEACH, VA 23455	1
BALOWIN, MOSS V.P.I. & S.U. P.O. BOX 325 BLACKSBURG, VA 24060	14	Bu, G. V.P.I. & S.U. DEPT OF BIOCHEMISTRY BLACKSBURG, VA 24061		COLEMAN, ALAN C. JAMES MADISON UNIVERSITY DEPT OF PHYSICS HARRISONBURG, VA 22807	
BARANOW, STEVEN 201 1/2 E. MAIN STREET CHRISTIANSBURG, VA 24073	3	BUCHHEIT, RUDOLPH G. UNIVERSITY OF VIRGINIA DEPT OF MATERIALS SCIENCE CHARLOTTESVILLE, VA 22901	6	COLWELL, CHRIS S. UNIVERSITY OF VIRGINIA BIOLOGY DEPT GILMER HALL CHARLOTTESVILLE, VA 22901	4
BATEMAN, TY T. JAMES MADISON UNIVERSITY DEPT. OF PHYSICS, BOX 315 HARRISONBURG, VA 22807	2	BURMESTER, JENNIFER L. COLLEGE OF WILLIAM AND MARY GEOLOGY DEPT, SKALL HALL WILLIAMSBURG, VA 23185	8	COMEAU, JAY L. VPI & SU 1020 DERRING HALL BLACKSBURG, VA 24061	4
BEALE, MARK L. 617 TAPANINGO ROAD S.W. VIENNA, VA 22180	4	BYLES, RICHARD A. 302 SOLANO, H ALBUQUERQUE, NM 87108		COMPTON, DAVID R. MCV-VCU BOX 613 MCV STATION RICHMOND, VA 23298	9
BELL, LEONARD W. 708 CIRCLE DRIVE BLACKSBURG, VA 24060	5	BYRD, DAVID W. 1603 HELENA AVE NORFOLK, VA 23505		COOK, CHRISTOPHER JOHN 3901 CUTSHAW AVENUE, APT. 3 RICHMOND, VA 23230	5
BELLUNDO, SARAH A. VA INST OF MARINE SCIENCE ELDWICESTER POINT, VA 23062		CAMPBELL, KENNY W. 1121 ARBORE DRIVE LYNCHBURG, VA 24501	6	CORNELIUS, PAMELA B. C/O JAMES E. PERHAM, BIOLOGY DEPT RANDOLPH-MACON WOMAN'S COLLEGE LYNCHBURG, VA 24503	4
BIDWELL, JOSEPH R. V.P.I. AND S.U. DEPT. OF BIOLOGY BLACKSBURG, VA 24060	4	CAPELLUTI, E. V.P.I. & S.U. DEPT OF BIOCHEMISTRY BLACKSBURG, VA 24061	5	COSTLOW, JANICE M. 921 ROCKBRIDGE AVENUE NORFOLK, VA 23508	9
BISSELL, LES D. JAMES MADISON UNIVERSITY DEPT. OF PHYSICS, BOX 315 HARRISONBURG, VA 22807		CARNEAL, ROBERT W. 2111 GINTER STREET RICHMOND, VA 23228	4	COTTER, HENRY VAN TUYL V.P.I. & S.U. BIOLOGY DEPT, DERRING HALL BLACKSBURG, VA 24061	14
BONAIDUCE, MICHAEL J. 102 COLLEGE ROAD RICHMOND, VA 23229	4	CESTONE, PAUL J. GEORGE MASON UNIVERSITY 6005 FRONTIER DRIVE SPRINGFIELD, VA 22150		O'ANGELO, DONNA JEAN 200 TANGLEWOOD DRIVE CHRISTIANSBURG, VA 24073	4
BONNETTE, EDWARD D. VPI & SU 3550 ANIMAL SCIENCE BLACKSBURG, VA 24061		CHABERS, RANDOLPH M. UNIVERSITY OF VIRGINIA HALL DEPT OF ENV SCI, CLARK HALL CHARLOTTESVILLE, VA 22903	15	DALAL, VISTASP P. OLD DOMINION UNIVERSITY 711 VIRGINIA AVE APT #2 NORFOLK, VA 23508	8
BOOS, VERNA C. 700 N. NASENMOND STREET, #1 RICHMOND, VA 23221	4	CHEN, PENGYIN VPI & SU DEPT OF AGRONOMY BLACKSBURG, VA 24061	1	DAVENPORT, J. DAVID OLD DOMINION UNIVERSITY 913 GREENWAY CT APT 2 NORFOLK, VA 23507-1440	9



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DELP, VICTORIA ELLEN V.C.U., DEPT OF BIOLOGY 816 PARK AVE. RICHMOND, VA 23220	4	GAVIN, ANGELIQUE ALIDA 4911 NEWPORT AVE. - APT #3 NORFOLK, VA 23508	10	HMIDA, JOHN A. V.P.I. & S.U. DEPT. OF BIOLOGY BLACKSBURG, VA 24061-0794	4
DICKENSON, ROGER C. UNIV. OF VA., THORNTON HALL DEPT. OF MATERIALS SCIENCE CHARLOTTESVILLE, VA 22901		GILMER, LINDA L. OLD DOMINION UNIVERSITY DEPT OF BIOLOGY NORFOLK, VA 23508		HOOVER, ANNE P. SUNY COL OF ENV SCI & FORESTRY 320 BRAY HALL SYRACUSE, NY 13210	15
DIFFOOT, NANETTE BIOLOGY DEPT VPI BLACKSBURG, VA 24061		GOGGIN, THOMAS W. 345 RESEARCH DR #180 ATHENS, GA 30605-2740	9	HOSSAIN, AMMAR 830 W 49TH ST APT #3 NORFOLK, VA 23508	12
DOOLEY, JAMES L. JR. UNIVERSITY OF VIRGINIA DEPT. OF ENVIRON. SCIENCES CHARLOTTESVILLE, VA 22903	15	GOODIN, JOHN T. UNIVERSITY OF RICHMOND NEED LOCAL ADDRESS	4	HOSTETLER, KEITH A. P.O. BOX 267 NCV STATION RICHMOND, VA 23298	9
ELDER, JOHN E. JR. VPI & SU RT. 1, BOX 448 ELLISTON, VA 24087	4	GREGORY, CHRISTINE J. 1518 MELROSE PKWY #B NORFOLK, VA 23508	4	HWANG, JEN-ING 921 ROCKBRIDGE AVENUE, APT #272 NORFOLK, VA 23508	2
ELLIOTT, CAROL D. MARY BALDWIN COLLEGE STAUNTON, VA 24401		GUNER, OSMAN F. VA. COMMONWEALTH UNIV. 1001 W. MAIN STREET RICHMOND, VA 23284		IAMS, HELEN D. MARY BALDWIN COLLEGE STAUNTON, VA 24401	
ESTES, JOAM H. 1303 OREGON AVE WOODBRIIDGE, VA 22191	4	HADLEY, CHRISTINA LEE 3 RENA ST ALLSTON, MA 02134		JENKINS, DAVID G. V.P.I. & S.U. DEPT. OF BIOLOGY, OERRING HALL BLACKSBURG, VA 24061	15
FAUSTINO, ALAN HERBERT 710 IITH ST RADFORD, VA 24141	9	HALAMA, KENNETH J. DEPT. ENVIRONMENTAL SCI. CLARK HALL, U. OF VA. CHARLOTTESVILLE, VA 22903	4	JERVIS, CHARLES K. VPI & SU 2400 A FOIRIDGE BLACKSBURG, VA 24060	14
FAZELI-NATIM, SIMA OLD DOMINION UNIVERSITY DEPT OF BIOLOGY NORFOLK, VA 23508	4	HALEY, CAROL JEAN 709 ASCOT LANE BLACKSBURG, VA 24060	15	KANITKAR, PARAG 7109 FERNWOOD ST, APT 2334 RICHMOND, VA 23228	4
FISHEL, SAMUEL E. 2004 ANN PORTSMOUTH, VA 23704	4	HALL, ELMORE SCOTT RT. 2 BOX 83-A BEAVERDAM, VA 23015	10	KERPELHAW, JENNIFER L. 1683 SHEPPARD AVENUE NORFOLK, VA 23518	10
FISHER, CHRISTINE R. PO BOX 11916 LYNCHBURG, VA 24506	15	HALL, STANLEY C. 164 FAIRMONT CIR DANVILLE, VA 24541	9	KIFLE, YESHIRAREG 7504 STONETRAIL WAY REYNOLDSBURG, OH 43860	3
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FREEMAN, THOMAS B. V.P.I. & S.U. BIOLOGY DEPT BLACKSBURG, VA 24061	4	HATCH, PHILLIS H. 9338 HELENWOOD DR FAIRFAX, VA 22032	4	KING, MARY LOU JAMES MADISON UNIVERSITY DEPT OF BIOLOGY HARRISONBURG, VA 22807	14
FRENCH, CHARLES R. VA COMMONWEALTH UNIVERSITY BOX 2012, BIOLOGY DEPT RICHMOND, VA 23284	4	HICKS, KAREN 414 NICEWOOD DRIVE NEWPORT NEWS, VA 23602	10	KIOUPPIS, MARIA VA COMMONWEALTH UNIVERSITY DEPT OF BIOLOGY, BOX 2012 RICHMOND, VA 23284	4
FRIEDLANDER, ALAN MARC 4 WOODSHIRE CT BALTIMORE, MD 21207-2224	15	HICKS, RAY C. HAMPTON-SYDNEY COLLEGE P.O. BOX 287 HAMPTON-SYDNEY, VA 23943	10	KRAMER, BRIAN 22A MCDONALD STREET APTS BLACKSBURG, VA 24060	10

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LATHAM, KEITH E. 24-B COPELY HILL CHARLOTTESVILLE, VA 22903	4	MEYERSON, RANDI M. V.P.I. AND S.U. BIOLOGY DEPT BLACKSBURG, VA 24060	4	PALMER, HUGH C. JR 497 W. JUMPER AVENUE HIGHLAND SPRINGS, VA 23075	4
LEWIS, ROBERT J. 10307 CLEVELAND ST FAIRFAX, VA 22030	4	NIKI, TAIRA OLO DOMINION UNIVERSITY DEPT OF CHEMISTRY NORFOLK, VA 23508	5	PAULSON, DANIEL MARK 1217 CLONKURRY ROAD NORFOLK, VA 23505	9
LITTLE, PATRICK J. MCV-VCU BOX 613 MCV STATION RICHMOND, VA 23298	9	MILLER, EDWIN J. 6200 G TERRACE VIEW BLACKSBURG, VA 24060	15	PERDUE, SAM P.O. BOX 816 CHESTER, VA 23831	
LORENZ-ELWOOD, JENNIFER 11144 THOMPSON CIRCLE FORT EUSTIS, VA 23604	4	MONTGOMERY, LOUISE B. 905-A NORTH HAMILTON ST RICHMOND, VA 23221	9	PETERSON, DIRK E. OLO DOMINION UNIVERSITY DEPT BIOLOGICAL SCIENCES NORFOLK, VA 23517	
LOUGH, TOM 115 SHASTA COURT CHARLOTTESVILLE, VA 22903	2	NOTA, MANUEL M. VP1 & SU DEPT PPWS BLACKSBURG, VA 24061	1	PHILLIPS, JAMES S. 1630 MELROSE PARKWAY NORFOLK, VA 23508	4
LUUKKONEN, DAVID R. V.P.I. & S.U. DEPT OF FISHERIES AND WILDL SCIENCES BLACKSBURG, VA 24061		MURPHY, MICHAEL P. V.P.I. AND S.U. DEPT. OF CHEMISTRY BLACKSBURG, VA 24061		PICKETT, HAL 1320 DE BREE AVENUE NORFOLK, VA 23517	10
MAGEE, JAMES TIMOTHY 1726 HANOVER AVE RICHMOND, VA 23220	4	MCCOY, JOHN W. THORNTON HALL - UNIV. OF VIRGINIA DEPT. OF MATERIALS SCIENCE CHARLOTTESVILLE, VA 22901		PILLAY, MICHAEL VP1 & SU DEPT OF BIOLOGY BLACKSBURG, VA 24061	14
MALICK, AORIAN DEERING HALL - BIOLOGY DEPT. V.P.I. & S.U. BLACKSBURG, VA 24061	3	MCCRARY, KENNETH WAYNE 188 W. HANBURY RD CHESAPEAKE, VA 23520	4	PODRATA, KENNETH F. 507 SMOKETREE PLACE RICHMOND, VA 23236	5
MALONE, MAUREEN E. 2059 ARCH DRIVE FALLS CHURCH, VA 22043	4	MCMAIRY, WILLIAM W. DEPT. OF PHYSICS, UVVA MCCORMICK ROAD CHARLOTTESVILLE, VA 22903	2	POIANI, KAREN A. RO 1 BOX 224 BLACKSBURG, VA 24060-9701	
MARINE, JEFFREY B. JAMES MADISON UNIVERSITY DEPT OF BIOLOGY HARRISONBURG, VA 22807	4	NING, JOHN T. 4219 OLO LYNE RD VIRGINIA BEACH, VA 23456-5310	9	PONTASCH, KURT WALTER V.P.I. AND S.U. UCES AND BIOLOGY DEPT. BLACKSBURG, VA 24061	15
MARTIN, ROBERT P.O. BOX 1447 LEXINGTON, VA 24450	9	O'REILLY, ROBERT L. 627 MCANHORME DRIVE NEWPORT NEWS, VA 23605-1019	14	POWEL, ANN C. 3517 QUEEN ANNE DRIVE FAIRFAX, VA 22030-1830	
MARTIN, THOMAS J. 5361 WHETSTONE DRIVE RICHMOND, VA 23234	9	OBANDO, R. OLO DOMINION UNIVERSITY ECE - DEPT NORFOLK, VA 23508	7	PRESCOTT, WILLIAM R. 11203 INGELLSTON ROAD RICHMOND, VA 23233	9
MAURAKIS, EUGENE G. 1205 SOUTH EDGEWOOD STREET #2 ARLINGTON, VA 22204	4	ORVOS, DAVID R. V.P.I. & S.U. DEPT. OF BIOLOGY BLACKSBURG, VA 24061	4	PRESTON, BRET A. V.P.I. & S.U. DEPT FISH AND WILDLIFE SCIENCES BLACKSBURG, VA 24061	15
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# THE VIRGINIA JOURNAL OF SCIENCE

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Guliday, John E. 1971. Pleistocene History of the Appalachian Mammal Fauna. In *Distributional History of the Southern Appalachians, Part III. Vertebrates* (Perry C. Holt, ed.), pp. 223-262. VPI & SU, Blacksburg, Va.

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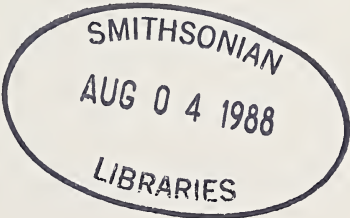
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**Abstracts of Papers Presented at the  
Sixty-sixth Annual Meeting, Virginia Academy of Science  
May 24-27, 1988, University of Virginia, Charlottesville, Virginia**

**Aeronautical and Aerospace Sciences**

3-D VISCOUS FLOW COMPUTATIONS ON EMBEDDED GRIDS USING AN IMPLICIT, UPWIND SCHEME. O. Baysal, V.R. Lessard, and K. Fouladi, Mechanical Engrg. and Mechanics Dept., Old Dominion Univ., Norfolk, VA 23529. One of the challenges of CFD for complex single or multicomponent configurations is the generation of a single body-fitted grid. This problem is substantially simplified by decomposing the physical domain into subdivisions, for each of which a single conforming grid is generated. These grids are then either embedded into or overlapped with the grids of other subdivisions. As the separate grids are to be treated as separate entities, boundary conditions must also be provided at the intergrid boundaries. A scheme is adapted where the conserved fluid variables are communicated between the grids via trilinear interpolations and locally one-dimensional method of characteristics. The Navier-Stokes equations are solved on these grids implicitly using a finite-volume, flux-difference splitting scheme. The methodology is tested by embedding a C-0 type grid, which is around a blunt-nose-cylinder, into a Cartesian grid. The freestream conditions are supersonic, and turbulent. The results obtained are then compared with previously benchmarked computations on a single grid. Then computations are performed for the supersonic flow past a cylinder in the proximity of a flat plate and they are compared with experimental results.

NAVIER-STOKES ANALYSIS OF COLD SCRAMJET EXHAUST FLOW. O. Baysal and W. C. Engelund<sup>\*</sup>, Mechanical Engrg. and Mechanics Dept., Old Dominion Univ., Norfolk, VA 23529. Propulsion/airframe integration for hypersonic, airbreathing vehicles is an important feature of National Aero-Space Plane configurations. The afterbody expands the supersonic and turbulent engine exhaust and therefore it becomes a part of the nozzle. The hypersonic freestream and the exhaust flow mix through a shear layer which includes shocks and expansions. The actual chemistry is not a first order effect in simulating this flowfield. A grid is generated to fit the contours of the nozzle. The cells that coincide with the cowl, which fall inside of the computation zone, is treated with a "blanking" strategy. That is, although these cells are computed, the changes in the dependent variables always ensure the no-slip wall conditions. Two-dimensional full Navier-Stokes equations are solved implicitly using a finite volume, upwind-biased scheme. Results are presented for preliminary cases where the exhaust fluid is assumed to be air. Then the ratio of the specific heats of the hot exhaust flow is matched by a cold simulant gas mixture of Freon and Argon. The equations are then modified to account for the mass diffusion of different species (Freon and Argon for exhaust flow, Oxygen and Nitrogen for freestream). Results are presented for a test run case.

A COMPUTER-VISION MEASUREMENT SYSTEM FOR DETERMINING THE SHAPE OF A FLEXIBLE AIRFOIL. C. Scott Blandford and George R. Webb, Dept. of Physics, Christopher Newport College. 50 Shoe Lane, Newport News, VA 23606.

Lift and drag characteristics for a flexible, deformable airfoil depend critically on the foil's shape, a time-dependent surface that is changed both by active controls and by the foil-fluid interaction. Determining the shape and then selecting the shape that is most suitable for a particular operating condition, in the case of sail-powered ships for example, has been in the past largely an operation of the skipper's judgement and experience. We have developed a measurement system that determines the shape of a flexible airfoil during operation. The system locates for a set of sections of the foil the positions of maximum draft and the values of the camber. Furthermore, this representation of the shape of the sections can be updated every 5 seconds.



AN APPLICATION OF GLOBAL OPTIMIZATION ALGORITHM FOR MODAL PARAMETER IDENTIFICATION. Chung-Wen Chen & Jen-Kuang Huang, Dept. of Mechanical Engineering and Mechanics, Old Dominion University, Norfolk, Va. 23529-0247. Single-Mode Projection Filters (SMPF), a new method for modal parameter identification for flexible structures, is introduced. The modal parameters required for formulating the filter are initially obtained from an analytical model. The test data are then passed through the parallel processing filters to identify the modal frequencies and modal dampings for the system. In order to update the filter parameters, a two-dimensional global optimization algorithm using the interval analysis method is applied to minimize a cost function defined by the norm of a specified error matrix. This algorithm guarantees finding the global minimum of any nonlinear function throughout a specified closed region of variables if the cost function is secondarily differentiable. A numerical simulation demonstrates the feasibility and effectiveness of SMPF as well as the global optimization method.

A FINITE ELEMENT LARGE DEFLECTION MULTIPLE-MODE RANDOM RESPONSE ANALYSIS OF STRUCTURES SUBJECTED TO ACOUSTIC LOADING. C. K. Chiang\* and Chuh Mei, Dept. of Mechanical Engineering and Mechanics, Old Dominion Univ., Norfolk, Va. 23529-0247. A finite element multiple modes procedure is developed for the large deflection random response analysis of beam and plate structures subjected to acoustic loading. System nonlinear stiffness matrix is set up for elements to account for the membrane force due to large deflection. The membrane force in each element is evaluated at the Gaussian points. Solution procedure is based on an iterative scheme. The root-mean-square (RMS) nondimensional maximum deflections, RMS maximum micro-strains, and equivalent linear frequencies of beams and plates using single-mode finite element method at various sound pressure levels are compared with the solutions using the Fokker-Planck-Kolmogorov equation method and equivalent linearization (EL) method. The finite element multiple-mode results for beams are compared with the solutions using the EL method. The comparisons showed that the present finite element formulation gives accurate random response predictions. (Supported by AFOSR Grant F33615-86-C-3230 and NASA-Langley Research Center Grant NAS1-17993-22)

ASPECTS OF COMPUTATIONAL WING DESIGN FOR SUPERSONIC AIRCRAFT. Davy A. Haynes, NASA Langley Research Center, Hampton, Virginia 23665. A computational study has been conducted to determine the general effects of airfoil profile, spanwise twist, and spanwise camber on the supersonic aerodynamics of a  $65^\circ$  delta wing. The NCOREL code, a non-linear full-potential solver, was utilized to obtain inviscid flowfield solutions for a Mach number range of 1.60-2.00 with a lift coefficient range of interest of 0.-0.3. The objective was to maximize lifting efficiency by minimizing the zero-lift wave drag and drag-due-to-lift parameters. In the analysis, the primary figure of merit was taken to be the maximum (inviscid) lift/drag ratio. The results of the study indicate that airfoil profile can be optimized for minimization of zero-lift wave drag with little effect on drag-due-to-lift characteristics. Twist and camber can be optimized for improved drag-due-to-lift although care must be taken to avoid large camber drag penalties. The study further indicates that delta wings can be optimized over a wide range of flight conditions, and that appropriate selection of airfoil profile, twist, and camber may increase lifting efficiency on the order of 10 percent.

**INCLUDING LIFE CYCLE COST IN CONCEPTUAL DESIGN.** Vicki S. Johnson and M. Leroy Spearman, NASA Langley Res. Ctr., Mail Stop 412, Hampton, Va. 23665-5225. The inclusion of life cycle cost (LCC) as early as possible in the conceptual design process is necessary because of the strong input the early design effort has on the total cost of an aircraft program. Recent improvements in computer capabilities and development of codes specifically oriented toward conceptual aircraft design make it possible to consider cost simultaneously with other conceptual design variables. A methodology is described which will incorporate life cycle cost in the conceptual design process for subsonic commercial aircraft. The methodology makes it possible to identify an aircraft concept that will meet the mission requirements and have the lowest LCC. The methodology consists of a LCC module composed of elements to calculate RDT&E (Research, Development, Testing, and Evaluation) cost, production costs, DOC (Direct Operating Cost), and IOC (Indirect Operating Cost) and an existing conceptual design and analysis code, the Flight Optimization System (FLOPS). Provision is made in the methodology for sensitivities to advanced technologies to also be investigated, allowing the merit of decreases in operating costs to be weighed against the increases in acquisition cost and vice versa.

**ENHANCED RELIABILITY OF THE TWO-POINT BOUNDARY-VALUE PROBLEM ASSOCIATED WITH THE OPTIMAL ATTITUDE CONTROL OF SPACECRAFT.** Yiing-Yuh Lin\* and L. Glenn Kraige\*, Dept. of Engineering Science & Mechanics, VPI & SU, Blacksburg, VA 24061. The solution reliability of two-point boundary-value problem associated with the optimal attitude control of rigid spacecraft is enhanced through a combination of techniques. Major emphasis is placed upon the formulation of the best possible starting or nominal solution. Constraint relationships among the state and costate variables are utilized. A hybrid approach which begins with the direct gradient method and ends with the indirect method of particular solutions is proposed. Test cases results which indicate improved reliability are presented.

**HYPERSONIC, LOW DENSITY FLOW PAST A CYLINDRICAL, LEADING EDGE STRUCTURE: DIRECT SIMULATION MONTE CARLO CALCULATIONS.** William W. Roberts, Jr. & Doris A. Cook., Dept. of Applied Mathematics, Univ. of Va., Charlottesville, Va. 22903. Hypersonic, low density gas flow in the transition regime between continuum and rarefied flows is studied past a cylindrical leading edge structure. An "N-body" computational code based on Monte Carlo techniques is developed for these purposes. We focus on the bow shock induced in the gas flow by the cylindrical leading edge structure whose size is comparable to that of the gas collisional mean free path. High resolution results are attained on the CRAY X-MP at the Pittsburgh Supercomputing Center where advantage is taken of large storage capacity and fast execution times. Regardless of the degree of computational resolution beyond a critical threshold, the computed width of the bow shock is found to be largely invariant. It is concluded that the computed flow characteristics are an accurate representation of the real physical flow characteristics for the low gas densities studied in this transition regime of interest. (This research was supported in part by NSF under Grants AST-82-04256 and AST-87-12084 and NASA under Grant NAGW-929).



A PASSIVE VENTING SYSTEM FOR REDUCING CAVITY DRAG AT SUPERSONIC SPEEDS. Floyd J. Wilcox, Jr.,\* NASA Langley Research Center, Hampton, Virginia 23665-5225. At supersonic speeds, the drag of rectangular cavities having length-to-height ratios approximately equal to or greater than 12 is substantially greater than for smaller length-to-height ratios. This increase in drag is associated with a change in the cavity flow field resulting in an increase in pressure ahead of the cavity rear face and a decrease in pressure downstream of the forward face. An experimental investigation was conducted to determine the effectiveness of a passive venting system for reducing this cavity drag increase. The passive venting system consisted of a cavity which had a porous floor with a vent chamber beneath the floor. It was expected that the high-pressure air at the rear of the cavity would vent to the low-pressure region at the front of the cavity thus modifying the cavity flow field and reducing the cavity drag. The wind-tunnel model consisted of a cavity mounted in a flat plate such that only the cavity drag was measured. Both solid and porous floor configurations were tested at Mach numbers of 1.6, 1.9, 2.16, and 2.86. The solid floor cavity results showed the typical large drag increase as the cavity length-to-height ratio was increased; the porous floor cavity eliminated this drag increase.

## Agricultural Sciences

EXPERIMENTAL DESIGN FOR ASSESSING SPACING EFFECTS ON DEVELOPMENT OF LOBLOLLY PINE STANDS. Ralph L. Amateis,\* Harold E. Burkhart and Shepard M. Zedaker,\* Dept. of Forestry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Forest managers vary planting density in order to achieve specific production goals. Experimental results from spacing trials are essential when attempting to optimize planting density for specified objectives. In the spring of 1983, a set of loblolly pine (Pinus taeda L.) spacing trials was established in the Coastal Plain and Piedmont regions of Virginia and North Carolina. The experimental design chosen was non-systematic allowing the spacings to vary in two dimensions on a factorial basis. This layout creates plots of each spacing that vary in size with equal numbers of trees per plot. The plots form a compact block in which main effects are confounded with the row and column positions of the block. This experimental design and the selected spacings offer opportunities to examine the effects of spacing and density on tree growth, survival and stem form.

CHARACTERIZATION OF CREEP FEED CONSUMPTION BY NURSING PIGS. K. L. Barnett\*, E. T. Kornegay, C. R. Risley, M. D. Lindemann & D. R. Notter. Dept. of Anim. Sci., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Four trials were conducted to examine the pattern of creep feed consumption in 23 litters of nursing pigs. A 20% crude protein creep diet containing corn, soybean meal, dried whey and chromic oxide (1.0%) was added to assigned litters (CRE) at 10 d of age. Control pigs (11 litters) were not exposed to creep feed (CON). Fecal samples were obtained twice daily for observation of chromic oxide (indicative of consumption). Creep feed disappearance was calculated every 3 d. All baby pigs were denied access to sow feeders but had water ad libitum. Pigs were weighed weekly until weaned (avg 28 d). CRE litters began eating at 11 d of age and disappearance of creep feed increased linearly until weaning (P<.01). Creep feed consumption was variable from pig to pig and litter to litter (5 to 107 g avg consumption per pig). No differences were observed between CRE and CON litters in daily gain for the first 4 wk (.19 vs .21 kg) or in 4 wk body weights (5.6 vs 6.1 kg). Larger litters had lower birth weights (P<.05), lower 4 wk body weights (P<.09), as well as less feed disappearance per pig (P<.02). In summary, linear creep feed disappearance begins at 11 d of age until weaning with no effect on daily gain or body weight. While larger litters consumed more total creep diet than smaller litters, consumption per pigs was less.



INFLUENCE OF SUPPLEMENTAL VITAMIN E ON THE CELL-MEDIATED AND HUMORAL IMMUNE RESPONSE OF WEANED PIGS. E. D. Bonnette, E. T. Kornegay & M. D. Lindemann. Dept. of Anim. Sci., VA Polytechnic Inst. & State Univ. Blacksburg, VA 24061. Four trials using 96 crossbred pigs were used to measure the effects of dietary vitamin E levels (11, 110, 220, 550 IU/kg of feed) and housing temperature (18 or 30°C) on performance, serum and liver vitamin E, cortisol levels, antibody titers to sheep red blood cells (SRBC) and mitogen stimulation [concanavalin A (ConA), phytohemagglutinin (PHA), lysozyme] of white blood cells in four week old weaned pigs. The fortified basal diet (20% crude protein) contained corn, soybean meal, and dried whey. Pigs were injected with SRBC and lysozyme on day 0 and 17. White blood cells were harvested weekly for 5 weeks from fresh blood and the serum taken was frozen until analyzed. Pigs housed at 18°C had higher overall daily gain and feed intake ( $P < .05$ ), but similar feed:gain, mitogen stimulation, cortisol level, antibody titer, serum and liver vitamin E levels compared with 30°C. Serum and liver vitamin E concentrations increased linearly ( $P < .01$ ) as dietary levels of vitamin E increased. No differences were observed with PHA induced stimulation indexes, cortisol level, antibody production or performance due to supplemental vitamin E. However, lysozyme induced stimulation indexes were increased with 110 and 220 IU/kg of vitamin E ( $P < .10$ ). Therefore, supplemental vitamin E can increase certain mitogen induced stimulation of white blood cells, but not cortisol, antibody levels and performance were not responsive.

CONTROL OF LICE AND GRUBS ON CATTLE BY VARIOUS METHODS by Stephen W. Bullington\*, Dept. of Entomol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061, Michael G. Fletcher\*, Dept. of Entomol., North Carolina State University, Raleigh, N. C., & James E. Roberts, Sr., Dept. of Entomol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. In 1986 we conducted a test of two insecticides for controlling lice and grubs on cattle. We evaluated three treatments, Tramisol Paste/Warbex Pour-On, Ivomec Injectable, and a control. Both insecticidal treatments gave absolute control of lice; however, the numbers of lice observed on the control animals were so small that the differences between these and the insecticide treatments had no overall significance. Both insecticidal treatments significantly ( $P = 0.0001$ ) reduced numbers of cattle grubs; further, Ivomec gave significantly ( $P = 0.0001$ ) better control than the Tramisol Paste/Warbex Pour-On combination. All three groups of cattle lost weight; however, Tramisol/Warbex significantly ( $P = 0.0110$ ) increased weight loss by the cattle as compared both to the control and to Ivomec.

ROOTWORM CONTROL ON CORN. Stephen W. Bullington\* & James E. Roberts, Sr., Dept. of Entomol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Western corn rootworms, (Diabrotica virgifera LeConte) have recently become established in western Virginia on no-till corn. In 1987 we investigated the efficacy of a number insecticides, applied to the soil at planting, in reducing damage and yield loss by this insect. We ran three tests, with treatments for Counter 15G, Force 1.5G, Dyfonate 20G, Dyfonate 20G (M), Lorsban 15G, and Furadan 15G, as well as a control. In one test we had an additional entry for Fortress 10G, and in this larger test as well as one of the others, two treatments of Counter 15G were applied, one in a band, and one in a furrow. These same two tests showed significant differences in damage ratings both among the insecticides themselves and between various insecticides and the control. No test showed significant yield differences.

INTROGRESSION OF A GENE FOR RESISTANCE TO SOYBEAN MOSAIC VIRUS (SMV) FOR IMPROVING AN ADAPTED SOYBEAN CULTIVAR. G. R. Buss\*, P. Chen, Dept. of Agronomy, S. A. Tolin\*, Dept. of Plant Pathology, Physiology, and Weed Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va 24061. Essex soybean is a high-yielding cultivar and well adapted to Virginia, but susceptible to all the known strains of SMV. The cultivar, Epps, was chosen as a source of SMV resistance to backcross into Essex. Epps was selected because it contains Rsv from PI 96983, which is resistant to most of the identified SMV strains. However, there was some concern that the reaction to specific SMV strains might be modified by genetic or cytoplasmic factors separate from the major resistance gene, Rsv. Backcrossing was continued to the BC<sub>5</sub>, using a single strain of SMV for screening each generation. One line, V85-5344, which was homozygous for Rsv and similar in appearance to Essex, was selected for further evaluation. V85-5344 showed the same reactions as PI 96983 and Epps to 8 SMV strains, indicating that the resistance gene Rsv was transmitted intact as a single unit with no change in SMV reactions through the backcrossing procedures. No alteration of important agronomic traits was observed for the isoline V85-5344 in comparison to Essex.

DUAL CULTURE OF SOYBEAN CALLUS AND SOYBEAN MOSAIC VIRUS (SMV). P. Chen, G. R. Buss\*, Dept. of Agronomy, S. A. Tolin\*, Dept. of Plant Pathology, Physiology, and Weed Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va 24061. Two methods of establishing dual cultures of soybean callus and SMV were investigated with 11 SMV strains and 3 soybean genotypes. Callus was initiated by culturing hypocotyl tissue on Msoy agar medium. Uninfected callus was inoculated with SMV in vitro by a soak-prick method. Infected callus was also established by directly culturing explants from SMV-infected leaves onto both Msoy and MS agar media. The established SMV-infected callus cultures were maintained in light at 5, 10, 15, or 25°C, and transferred to fresh media when necessary. The presence and viability of the virus in callus cultures was tested by Ouchterlony double diffusion test, ELISA, and infectivity assay. The infected calli cultured in MS media grew better and longer (10-12 weeks) than those cultured in Msoy media (6-8 weeks). Low temperature greatly inhibited the growth of callus-SMV cultures, thus allowing them to propagate slowly in the media without frequent transfer. Callus-SMV cultures can be maintained for about 16 weeks at 10-15°C without subculture. No strain variation has been observed after in vitro propagation of the virus. Using this approach, we have successfully maintained SMV for a year.

REACTION OF SOYBEANS TO MIXED INOCULATION OF SOYBEAN MOSAIC VIRUS (SMV). P. Chen, G. R. Buss\*, Dept. of Agronomy, S. A. Tolin\*, Dept. of Plant Pathology, Physiology, and Weed Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va 24061. The reactions of 2 differential soybean cultivars to simultaneous inoculation with 28 two-strain combinations of SMV were studied for strain interaction. Greenhouse-grown plants were inoculated with either separate strain inoculum or mixed strain inoculum. The inoculated plants were examined for symptoms of infection and assayed for SMV by ELISA. Leaf sap from plants inoculated with virus mixtures was tested on indicator plants for strain recovery and identity. Plants inoculated with 2 avirulent strains showed resistant response, and no virus was detected in the inoculated plants. Plants inoculated with a combination of an avirulent strain plus a mosaic or a necrotic strain produced mosaic or necrosis, respectively. Plants inoculated with a mosaic and a necrotic strain gave mosaic reaction and the mosaic strain would be found in the inoculated plants. When plants were inoculated with 2 mosaic strains, mosaic symptoms would be observed and the more virulent mosaic strain would be recovered from the inoculated plants. The SMV strain relationships of virulence (dominance) could be described as mosaic > necrotic > avirulent. No difference was observed between the two inoculation methods.



REQUIREMENT OF GROWING-FINISHING PIGS FOR CALCIUM AND PHOSPHORUS: DEVELOPMENT OF RESPONSE CURVES FOR PERFORMANCE. N. R. Combs, E. T. Kornegay, M. D. Lindemann & D. R. Notter. Dept. of Anim. Sci., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Three trials involving 300 pigs totl (12 replicates) were conducted to establish a data base for evaluation of the effects of 5 dietary Ca/P levels (70, 85, 100, 115 and 130% NRC recommendation) on performance from weaning to market. The 100% NRC diet served as the control, and the other diets were formulated by varying  $\text{CaCO}_3$  and dicalcium phosphate in the diet. At weaning (10 kg avg.), pigs were blocked by sex and sire into 5 blocks per replicate (5 pigs per block, each randomly assigned to 1 of the 5 diets). One block per replicate was randomly chosen for slaughter every 4 wk. Pigs were weighed biweekly and pen feed consumption was determined, over the 140 d trials. Average daily gain (ADG) and average daily feed intake (ADFI) were linearly and quadratically dependent on the ratio of actual to expected total Ca:P intake (CAP) and day on test (T) ( $P < .0001$ ). Gain:feed ratios responded inconsistently to CAP and T, therefore, only ADG and ADFI response surfaces were developed. Asymptotic response surfaces were found to have a more desirable fit than linear models. Asymptotic ADFI and ADG response surfaces derived were:  $\text{ADFI} = (.446 + .0381\text{T} - .000134\text{T}^2)\{1 - (.00776\text{T} - .0000494\text{T}^2)e^{[-.0939](\text{CAP})}\}$ ,  $R^2 = .91$ ;  $\text{ADG} = (.378 + .0107\text{T} - .0000579\text{T}^2)\{1 - (.185 + .0230\text{T} - .00000598\text{T}^2)e^{[(-.0791)(\text{CAP})]}\}$ ,  $R^2 = .61$ .

EVALUATION METHODS FOR FUNGICIDE SPRAY ADJUVANT EFFECTS ON DISEASE CONTROL. R. M. Cu, P. M. Phipps & R. J. Stipes, Plant Pathology Dept., Virginia Tech, Blacksburg Va. 24060. Various methods were developed as proposed guidelines for fungicide spray adjuvant evaluation. Spray droplet contact angle and area of spray coverage were considered important parameters to characterize wettability and spray droplet distribution. Field evaluation allowed direct correlation of physical spray characteristics with disease control performance. The guidelines included: 1. plant part simulation; 2. characterization of droplet-surface phenomena; 3. field evaluation; 4. data analysis/synthesis; and 5. specific recommendation. As test for guideline fitness, soybean oil was evaluated for its adjuvant effect on chlorothalonil's efficacy against *Cercospora* leafspot. The results indicated increasing wettability and area of spray coverage at increasing levels of oil. Field evaluation, however, showed a rate-limiting fungicidal activity. The line fitting curve of percent infection plotted against increasing oil concentration exhibited a quadratic polynomial curve with optimum level of adjuvant between 0.5 and 1% of spray volume.

GROUNDSSEL CONTROL IN CONTAINER-GROWN ORNAMENTALS. Jeffrey F. Derr, Va. Polytech. Inst. & State Univ., Hampton Roads Ag. Exp. Station, Virginia Beach, Va 23455. Experiments were conducted to evaluate experimental herbicides for controlling common groundsel (*Sencio vulgaris* L.) in 'Hinocrimson' azalea, Dwarf nandina, 'Bennetts compacta' holly, photinia, 'Sea green' juniper, inkberry and liriope. Chlorsulfuron at 0.016 and 0.06 lb/A injured all species except holly. Chlorimuron and CGA-1036, both at 0.016 and 0.06 lb/A, did not injure holly, juniper or inkberry but did damage the remaining species. Isoxaben at 0.75 lb/A appeared to be safe on all species tested. Chlorimuron, CGA-1036 and chlorsulfuron provided essentially 100% groundsel from preemergence treatments. Isoxaben provided approximately 80% control. Oryzalin at 2.0 lb/A provided 50% groundsel control while a granular combination of oxyfluorfen plus pendimethalin at 3.0 lb/A resulted in 90% control.



REPRODUCTION OF THE NORTHERN ROOT-KNOT NEMATODE, MELOIDOGYNE HAPLA, ON THREE SPECIES OF MARIGOLDS. J. D. Eisenback, Dept. of Plant Path., Physiology and Weed Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va 24061. The ability of ten populations of Meloidogyne hapla to reproduce on three species of marigold, Tagetes filifolia, T. erecta, and T. patula, was evaluated in greenhouse experiments. The populations of M. hapla belonged to two cytological races. Race A included six facultatively parthenogenetic populations with haploid chromosome numbers of 14, 15, 16, 17, 30, and 31. Race B consisted of four obligatory parthenogenetic populations with polyploid chromosome numbers of 43, 45, 45, and 48. All ten populations reproduced on T. filifolia; only cytological race B populations reproduced on T. patula. Only one population, a cytological form (race A) with 17 chromosomes from Virginia, reproduced on T. erecta. Additional studies may confirm the correlation between race B and the ability to reproduce on T. patula, so that in the future these races may be identified by a differential host test.

SYMPLASTIC AND APOPLASTIC TRANSPORT OF RUBIDIUM IN PIN OAK FOLLOWING FLARE ROOT INJECTION OF RUBIDIUM CHLORIDE. S. J. Fleischer, F. W. Ravlin, Dept. of Entomology and R. J. Stipes, Dept. of Plant Pathology and Weed Science, VPI & SU, Blacksburg, VA 24061. The movement of rubidium (Rb) in pin oak was studied to develop trace element labelling for dispersal studies of tree arthropod herbivores. Foliar Rb concentrations were directly proportional to the rate of injection four days and later post-injection. Foliar concentrations were asymptotic with time at about 12 days post-injection. Lower injection rates gradually approached the asymptote, whereas higher rates resulted in an initial peak about 7 days post-injection followed by a decrease to asymptotic levels. Significantly higher foliar concentrations were found in the upper portion of the tree. Toxic symptoms were observed on leaves at rates  $\geq 200$  g RbCl per tree and were related to the position of the tree on a slope. Outer xylem and inner bark held Rb concentrations proportional to injection rate 5 months after injection. All life stages and F<sub>1</sub> eggs of gypsy moths were successfully labelled by feeding on foliage from Rb-injected trees. The proportion of Rb retained through the pupal molt was sexually dimorphic.

LABORATORY AND GREENHOUSE TECHNIQUES FOR STUDYING OROBANCHE. C. L. Foy. Dept. of Plant Path., Physiol. and Weed Sci., Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061. Broomrapes (Orobanche spp.) are phanerogamic holoparasites which subsist on the roots of many economically important broad-leaf plants. The genus contains 150 or more species, some of which have a wide host range and devastating potential. Crops most seriously affected by broomrapes are broadbean, tomato, potato, tobacco, sunflower and pea. O. ramosa, O. minor and O. ludoviciana exist in the U. S. and could, potentially, cause extensive crop damage. Control of broomrape is extremely difficult and/or expensive. Better understanding of host/parasite relationships is needed to develop improved strategies for broomrape eradication or control. Several simple laboratory and greenhouse techniques were devised and employed to study the inducement of germination, attachment and parasitic development of Orobanche spp. on selected crop hosts: (a) use of stigol analogues or root exudates from host or "trap" crops to "trigger" germination *in vitro* and/or *in vivo*; (b) greenhouse or growth chamber bioassays to determine broomrape-host specificities; (c) radiotracer procedures to chart <sup>14</sup>C-glyphosate distribution in the host and parasite; and (d) hydroponic culture, agar plate-petri dish and "sandwich" techniques for growing broomrape in a soilless system.

MOBILITY AND PERSISTENCE OF SELECTED SOIL-ACTIVE HERBICIDES USED IN NO-TILL CORN. Chester L. Foy and John S. Wilson\*, Dept. of Plant Path., Physiol., and Weed Sci., Virginia Polytech. Inst. and State Univ., Blacksburg, VA 24061. Alachlor, metolachlor, atrazine, cyanazine, and simazine, the leading soil-applied herbicides for corn, have the potential to contaminate groundwater and carry over into sensitive crops. Greenhouse studies, leaching and repeated cropping using oats as an indicator species, were conducted to determine their relative mobility and persistence in the following soil types: loam, silt loam, clay, sandy loam, and loamy sand. Atrazine remained in the upper 25 cm of the loam and silt loam soils and moved throughout the other soils. Results with simazine were similar. Cyanazine caused reductions in the dry weight of oats in the upper portion of the loam and throughout most of the loamy sand; metolachlor and alachlor had few (if any) adverse effects on oats in any soils. Herbicide response was rate-dependent and toxicity diminished with the second cropping. In the first cropping, cyanazine, representative of the triazines, showed the following order: loamy sand > clay > silt loam  $\approx$  sandy loam, loam and silt loam. Metolachlor injury followed the order of clay > loamy sand > silt loam. Atrazine exhibited greatest residual toxicity. Alachlor and metolachlor residues caused injury only at the highest rate.

IDENTIFICATION AND PATHOGENICITY TESTS OF PATHOGENS FROM THISTLES, MORNINGGLORIES AND HORSENETTLE. D. A. Johnson and A. B. A. M. Baudoin, Dept. of Plant Pathology, Physiology, and Weed Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Pathogens were collected in the field from weeds including bull thistle (*Cirsium vulgare*), plumeless thistle (*Carduus acanthoides*), tall morningglory (*Ipomoea purpurea*), and horse-nettle (*Solanum carolinense*). Isolates were screened for pathogenicity using an agar-mycelium inoculation technique. Spore inoculations of pathogenic isolates are in progress. Pathogens isolated from bull thistle include a *Fusarium* species and a member of the order Sphaeropsidales. Pathogens from plumeless thistle include two *Alternaria* species, a *Cercospora* species, two *Fusarium* species, and a member of the order Melanconiales. Pathogens from tall morningglory include a *Cercospora* species, a *Colletotrichum* species, a *Fusarium* species, and a *Rhizoctonia* species. Information obtained from these investigations will be used to assess the potential of the pathogens as biological weed control agents.

RECIRCULATION OF AIR IN PEANUT DRYING. G. D. Kulasiri\*, D. H. Vaughan, and J. S. Cundiff\*, Dept. of Agric. Engineering, VPI&SU, Blacksburg, VA. 24061-0303. Virginia type peanuts were dried in three laboratory dryers to investigate the energy saving potential of air recirculation. A dryer consists of four ducts having an inner uniform cross section of 0.5mx0.5m. The depth of the drying bed is 1.2m. The air is recirculated through a horizontal duct above the drying bed. The amount of recirculated air can be controlled. Air is heated using finned strip heaters which can be controlled to maintain air temperature at 35C. Two different recirculation schedules were used in the experiments. For schedule 1, 40% of the air was recirculated during the first 24 hours, 60% was recirculated during the next 24 hours, and 75% was recirculated during the last 24 hours. With schedule 2, the percentages of recirculation were 25%, 40%, and 60%, respectively. Energy savings were calculated with a computer model using measured electric current data. The energy consumption was 152.4 MJ and 204.3 MJ for schedules 1 and 2, respectively. Energy consumed without any recirculation was 338.1 MJ. Therefore, schedule 1 saved 55% of the heat energy and schedule 2 saved 39% of the heat energy.



SEASONAL CAPTURE OF WOOD BORING BEETLES IN VIRGINIA VINEYARDS. Michael W. Lachance and Douglas G. Pfeiffer, Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., 24061. Insect traps hung in commercial vineyards were employed to study the role of ethanol as a possible chemical compound mediating host plant selection for two families of wood boring beetles (Coleoptera: Scolytidae and Bostrichidae). Members of these families have been observed by state grape producers causing damage to grapevines. Eleven sites were monitored in seven Va. counties with acrylic vane traps placed within the vine canopy. The following physiographic provinces were included in the 1987 survey: the middle section of the Ridge and Valley, the northern section of the Blue Ridge, and the Piedmont Upland. Seventy percent ethanol was employed as a chemical attractant. Numerous species in these two families were collected during the growing season. The majority of the species were captured at the onset of warm weather although the species in greatest abundance, Xyleborinus saxeseni (Ratzeburg) did not display this seasonality. Boring activity was observed causing vine damage. A species of ambrosia beetle, genus Xylosandrus, and a bostrichid, Xylobiops basilaris (Say), were recorded as inflicting damage to the trunks and cordons in several of the vineyards surveyed.

Decolorization of Crystal Violet by Pseudomonas putida, F. McCuiston and C. Hagedorn, Dept. of Agronomy, VPI&SU, Blacksburg, VA 24061. Several thousand, Pseudomonas isolates were examined for control of Pythium ultimum and Rhizoctonia solani. Promising isolates were examined for selectable recovery traits. One disease reducing isolate was also found to decolorize crystal violet at up to 50 µg/ml. On agar, the color change produced a red halo within 24 hrs. In unshaken broth cultures, an insoluble red precipitate was formed in 2 to 4 weeks. The color change was sporadic on TSA and was inhibited by using  $\text{NH}_4^+$  or  $\text{NO}_3^-$  as sole N sources, although low  $\text{NH}_4^+$  concentrations did not inhibit the color change if asparagine was provided. In polar organic solvents, the precipitate dissolved and reverted to a bluish purple form that had identical TLC  $R_f$  values to crystal violet. The precipitate was insoluble in nonpolar solvents and retained its red color. Additionally, the precipitate did not dissolve in pronase but did dissolve in Triton-X-100 and turned blue. This evidence supports our hypothesis that a secondary metabolite associates with the crystal violet. To date, transposon mutagenesis has not produced any mutants lacking the decolorization trait.

MORPHOLOGICAL COMPARISONS OF ONE ISOLATE EACH OF HETERODERA GLYCINES, GLOBODERA TABACUM TABACUM AND ONE OF THEIR ROUND-ENDED HYBRIDS. L. I. Miller, Dept. of Plant Path., Phys., and Weed Sci., VPI & SU, Blacksburg, VA 24061. Comparisons were made of 31 second-stage juveniles and the perineal region structures of 21 young brown cysts of one isolate of Heterodera glycines (GL) cultured on 'Lee' soybean, one isolate of Globodera tabacum tabacum (GTR) cultured on Solanum dulcamara and one of their fertile round-ended hybrids (GTR) cultured on 'PA-1' tomato. Mean dimensions in µm were as follows [JUVENILES] length from base of stylet knobs to dorsal gland orifice: GL 4.4, TR 5.9, GTR 6.2; length from anterior end to anus: GL 412.2, TR 442.3, GTR 458.6; length of tail terminus: GL 25.9, TR 23.4, GTR 30.1. [ROUND-ENDED CYSTS] distance from anus to vulval fenestra (B): TR 41.7, GTR 51.3; length of vulval fenestra (L); TR 26.3, GTR 24.5; mean Granek's ratio (B/L): TR 1.5, GTR 2.1. GL, TR and GTR were significantly different ( $P = 0.05$ ) for all dimensions and the B/L ratios compared, except the fenestral length comparisons of TR (26.3) and GTR (24.5) which were not different ( $P = 0.01$ ). All juvenile comparisons for TR were intermediate between GTR and GL. GL did not reproduce on S. dulcamara, but reproduced well on soybean and poorly on tomato. TR and STR did not reproduce on soybean but reproduced well on S. dulcamara and tomato.



MORPHOLOGICAL COMPARISONS OF ONE ISOLATE EACH OF HETERODERA SCHACHTII, GLOBODERA TABACUM TABACUM AND ONE OF THEIR FERTILE INTERGENERIC HYBRIDS. L. I. Miller, Dept. of Plant Path., Phys., and Weed Sci., VPI & SU, Blacksburg, VA 24061. Comparisons were made of 31 second-stage juveniles and the perineal region structures of 21 young brown cysts of one isolate of Heterodera schachtii (SL) cultured on 'US75' sugarbeet, one isolate of Globodera tabacum tabacum (TR) cultured on Solanum dulcamara and one of their round-ended hybrids (STR) cultured on 'PA-1' tomato. Mean dimensions in  $\mu\text{m}$  were as follows — [JUVE-NILES] stylet length: SL 25.3, TR 23.2, STR 22.4; breadth of stylet knobs: SL 5.1, TR 4.3, STR 4.7; tail length: SL 44.7, TR 50.0, STR 52.2. [ROUND-ENDED CYSTS] distance anus to vulval fenestra (B): TR 41.2, STR 54.0; length of vulval fenestra (L): TR 26.4; STR 21.9; mean Granek's ratio (B/L): TR 1.6, STR 2.5. SL, TR and STR were significantly different ( $P = 0.01$ ) for all dimensions and B/L ratios compared. The B dimension and the B/L ratio of the cyst perineal region structures were greater for STR than TR. Dimensions for stylet length and breadth of knobs of juveniles were greater for SL than TR and STR but tail length of SL was less than that of TR and STR. SL reproduced well on sugarbeet but poorly on tomato. TR and STR did not reproduce on sugarbeet but reproduced well on S. dulcamara and tomato.

OPTIMIZATION OF STYLET EXTRACTION OF CYST NEMATODES. Manuel M. Mota, and J. D. Eisenback. Dept. of Plant Path., Physiology and Weed Science, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061. The soybean cyst nematode and the tobacco cyst nematode are two important pathogens causing extensive crop losses in Virginia. Sometimes these two species occur together in the same field. Species differentiation on the basis of morphology may enable nematode assay laboratories to provide growers with improved control recommendations. Stylet morphology is considered an important and stable taxonomic character; however, extraction of stylets from nematodes is often difficult and tedious. Aqueous solutions of lactic acid are suitable for stylet extraction in other nematode genera, yet they were unsuitable for stylet extraction from the cyst nematodes. In our studies, 0.01% sodium hypochlorite (NaOCl) optimized stylet extraction from both species of cyst nematodes. The morphology of sodium hypochlorite-extracted stylets was comparable in the scanning electron microscope to non-extracted stylets viewed by light microscopy.

IRRIGATION OF CORN USING A PERMANENTLY INSTALLED SUBSURFACE TRICKLE IRRIGATION SYSTEM. N. L. Powell and F. S. Wright, Virginia Tech, Tidewater Agricultural Experiment Station and USDA-ARS, Suffolk, Va. 23437. A subsurface trickle irrigation system installed 14-16 inches below the soil surface was used to irrigate corn during the 1986 and 1987 growing seasons. Corn yielded 125 and 50 bu/acre without irrigation in 1986 and 1987, respectively. With 4 and 5 inches of applied irrigation water in 1986 the corn yield was 142 and 145 bu/acre, respectively. With 6 and 9 inches of applied irrigation water in 1987 the corn yield was 137 and 173 bu/acre, respectively. Low operating cost allows the use of a permanently installed subsurface trickle irrigation system for corn when compared with other types of irrigation systems.

THE EFFECTS OF SEAWEED EXTRACTS ON PLANT GROWTH AND PEST RESISTANCE. Diane M. Reaver<sup>1</sup>, John M. Luna<sup>2</sup>, and Anton B. Baudoin<sup>1</sup>, <sup>1</sup>Dept. of Plant Path., Physiol., and Weed Sci. and <sup>2</sup>Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061. A commercial extract of kelp (Ascophyllum nodosum) was applied as a foliar spray on third and fourth cutting alfalfa (Medicago sativa L.) in fertilized and nonfertilized plots. Kelp treatments alone had no effect on alfalfa yield, on tissue levels of nitrogen, phosphorus, and potassium, or on naturally occurring populations of potato leafhopper (PLH), Empoasca fabae (Harris). For the fourth cutting, fertilizer and kelp\*fertilizer effects were observed. Yield and tissue levels of potassium were higher and PLH numbers were lower in fertilized plots compared to nonfertilized plots. PLH numbers were reduced in the fertilized plots to a level below economically damaging populations. In fertilized plots, kelp temporarily reduced numbers of PLH adults one week after kelp treatment, followed by reduced levels of PLH nymphs. Kelp had the opposite effect in the nonfertilized plots: PLH adult levels were initially higher, followed by increased numbers of nymphs. Fungal leaf spots on the top five leaves were reduced on fertilized plants compared to nonfertilized plants, on kelp-treated plants in nonfertilized plots compared to nontreated plants, and on plants treated with the insecticide dimethoate compared to nontreated plants.

EVALUATION OF CHRYSANTHEMUM CULTIVARS FOR RESISTANCE TO EUROPEAN CORN BORER, OSTRINIA NUBILALIS (HUBNER). R. B. Schultz & M. A. Coffelt. Dept. of Entomology, Va. Polytechnic Inst. & State Univ. Hampton Roads Agric. Exp. Sta. Virginia. Beach, VA 23455. Laboratory studies were conducted to evaluate selected yellow and bronze chrysanthemum cultivars for resistance to the European corn borer, Ostrinia nubilalis (Hubner). The results indicated yellow cultivars 'Freedom', 'Classic', 'Compatriot', and 'Fortune' and bronze cultivar 'Pancho' had significantly lower infestation percentages. All chrysanthemum cultivars grown in 2 Virginia nurseries were evaluated in field studies. The cultivar 'Fireside Cushion' was significantly lower at both nurseries, with cultivars 'Buckeye', 'Grenadine', and 'Viking' also having significantly lower infestation percentages. A significant positive correlation between infestation levels and stem diameters suggested stem thickness may be an indicator of host plant resistance.

FUNGITOXICITY OF EXPERIMENTAL FUNGICIDE RH-3486, CARBENDAZIM, FENPROPIMORPH AND THIABENDAZOLE TO THE GROWTH OF CERATOCYSTIS FAGACEARUM, CRYPHONECTRIA PARASITICA, ENDOTHIA GYROSA AND OPHIOSTOMA ULMI. F. D. Smith, R. J. Stipes and P. M. Phipps, Dept. Plant Pathol., Physiol. and Weed Sci., Virginia Tech, Blacksburg and Suffolk, VA.

The sensitivity (growth response) of Ceratocystis fagacearum (oak wilt), Cryphonectria parasitica (chestnut blight), Endothia gyrosa (pin oak blight) and Ophiostoma ulmi (Dutch elm disease) to four fungicides was tested on fungicide-amended glucose-yeast extract agar to establish dose-response curves and ED<sub>50</sub> values for each fungicide-pathogen interaction. Carbendazim and thiabendazole (benzimidazoles) completely inhibited growth at high levels and allowed normal growth at low levels; while RH-3486 and fenpropimorph partially inhibited fungal growth at very low concentrations, but did not completely inhibit growth at high concentrations. ED<sub>50</sub> values for RH-3486 were 0.105, 0.028, 0.0034 and 0.0033 µg/ml against C. fagacearum, O. ulmi, C. parasitica and E. gyrosa, respectively; values obtained with fenpropimorph were similar. Carbendazim and thiabendazole were between 10 and 100 times less effective in inhibiting growth.



EFFECTIVENESS OF AMMONIUM PROPIONATE ADDITION TO DIETS FOR WEANLING PIGS. L. A. Sweet & E. T. Kornegay, Dept. of Anim. Sci., VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Weanling pigs (n=222) were used in three feeding trials to evaluate the effectiveness of ammonium propionate for improving post-weaning performance and reducing scours. Pigs were randomly assigned to one of six dietary treatments in trials 1 and 2 according to sex, litter, and weight: 1) control, 2) diet 1 + .05% carbadox, 3) diet 1 + .15% ammonium propionate (AP), 4) diet 1 + .60% AP, 5) diet 1 + 1.2% AP, and 6) diet 1 + 1.8% AP; and to one of three dietary treatments in trial 3: 1) control, 2) diet 1 + .15% AP, and 3) diet 1 + 1.8% AP. The incidence and severity of scours, which were recorded every other day during the first two weeks and three times weekly for the remainder of the study, increased during the first eleven days and then decreased, but were similar among dietary treatments. Pigs fed diet 2 containing carbadox ate 14% more diet, grew 20% faster, and were 5% more efficient than pigs fed the control diet. Of pigs fed diets containing AP, only the lowest level of AP gave improved performance; they ate 7% more diet and gained 8% faster than the controls, but had similar feed per gain ratios. Although AP improved growth rate compared with controls, it was not as effective as carbadox.

ENERGETICS OF HERBACEOUS CROPS UNDER MARGINAL GROWING CONDITIONS. D. H. Vaughan and J. S. Cundiff\*, Dept. of Agric. Engineering, VPI&SU, Blacksburg, VA. 24061. Eight herbaceous crop species are being investigated for their potential to produce biomass under marginal soil and climate conditions in the Piedmont. The crops, planted on twelve Piedmont sites in Appling, Cecil and Davidson soils, are sorghum-sudangrass, switchgrass, lovegrass, tall fescue, sericea lespedeza, flat pea, crownvetch, and birdsfoot trefoil. Energy inputs including fuel, machinery, fertilizer, herbicides and other crop chemicals were determined and compared with yields to determine energy ratio and energy productivity. Energy analyses shows that both energy productivity (kg of yield per MJ of energy input) and energy ratio (energy output based on dry matter yield compared to energy inputs) are species-dependent, with the higher yielding, warm season grasses showing the greatest energy return.

MECHANIZATION OF THE SELECTIVE HARVEST OF COLE CROPS. J. H. Wilhoit\* and D. H. Vaughan, Dept. of Agric. Engineering, VPI&SU, Blacksburg, VA. 24061. Cole crops are vegetables of the species Brassica oleracea, including cabbage, cauliflower, broccoli, brussel sprouts, kohlrabi, and kale. Cole crops have growth characteristics that contribute to unique harvest requirements. The harvested parts are vegetative rather than fruit, so the plant is usually destroyed during the harvest. The plants do not mature uniformly, so they must be harvested selectively in several passes. High plant populations are used for better yields, so harvesting must leave closely spaced neighboring plants unharmed. Because the entire plant is harvested, further trimming of the harvested part is often required for marketing. Requirements for mechanizing the harvest of broccoli are representative of cole crops. An investigation of commercial broccoli harvest practices in Virginia and possible ways of mechanizing the harvest have been done. A manually-directed powered cutting device that partially mechanizes the selective harvest of broccoli has been built and tested. Harvest times with the device were approximately 50% lower than for commercial cutting by hand, although some additional leaf stripping was required.

AIRFLOW MEASUREMENT TECHNIQUES FOR AGRICULTURAL FANS. P. M. Winkelman\*, J. S. Cundiff\*, and D. H. Vaughan, Dept. of Agric. Engineering, VPI&SU, Blacksburg, VA. 24061-0303. Fan manufacturers provide published ratings indicating the amount of air their fans deliver when working against a specific static pressure. However, this static pressure is often difficult to measure, and thus, the actual amount of air the fan delivers is not known. Air entering an agricultural fan may be measured by providing the air from a supply fan which can be calibrated such that the amount of air supplied is known. Calibration is accomplished by passing the air across a perforated plate, and adjusting the supply fan until the pressure between the plate and inlet is zero. The plate is calibrated to give the flowrate from a measured pressure drop across it. For testing crop-drying fans out of season, a porous material such as cloth may be chosen and calibrated that simulates the resistance of the crop. Calibration is done by measuring the pressure drop across the simulated resistance when a known amount of air is passing through it. The flow of air is determined by measuring the pressure drop across a standard nozzle, or velocity pressure exiting a nozzle.



**EFFECTS OF SEEDING PATTERNS ON SWEET SORGHUM.** J. W. Worley\*, J. S. Cundiff\*, and D. H. Vaughan, Dept. of Agric. Engineering, VPI&SU, Blacksburg, VA. 24061-0303. A system is being developed for mechanically harvesting and processing sweet sorghum stalks for the production of edible syrup or ethanol. The goal of this research is to maximize yield of total nonstructural carbohydrates (TNC) while producing an erect stalk which can be mechanically harvested. Sorghum was planted at three populations both in hills and drilled in rows. Also, plots were planted with equal spacing in both directions. A study was also done to compare conventionally tilled plantings with no-till plantings. Due to the extremely dry growing season, the plants did not reach full maturity before frost, resulting in a reduction in yields and some biasing of the data. No-till planting showed an advantage in percent emergence, but a reduction in yields and stalk diameter compared to the conventional till system. The equal spacing plantings had higher yields and slightly improved stalk diameters as compared to the other seeding patterns. No other trends could be statistically documented.

**EVALUATION OF ASPIRIN IN DIETS FOR WEANLING PIGS.** Zi-rong Xu, E.T. Kornegay, L.A. Sweet, M.D. Lindemann & H. P. Veit. VA Polytechnic Inst. & State Univ., Blacksburg, VA 24061. Fifty-four (3 replicates of 3 pigs/pen/treatment) crossbred pigs, weaned at 3 to 4 wk of age, were used in a five wk trial to determine the effectiveness of aspirin in starter diets. Pigs were randomly assigned from outcome groups based on sex, litter and weight to trts: 1) basal (B), 2) B + 1250 ppm carbadox, 3) B + 250 ppm aspirin (acetylsalicylic acid), 4) B + 500 ppm aspirin, 5) B + 1000 ppm aspirin and 6) B + 500 ppm aspirin + 1500 ppm glucose + 683 ppm sodium acetate. An 18% crude protein corn-soybean meal diet was fed. Body weights and feed consumption were taken weekly. The incidence and severity of scours of each pig, which was evaluated and recorded every other day during the first two wk post-weaning and three times weekly thereafter, tended to be higher for controls compared with all other treatments. Hematocrit, hemoglobin and blood clotting time, determined at the termination of the trial, were not significantly affected by treatments. One pig in each pen was killed for gross examination; a few stomach lesions were observed but were not related to treatments. Daily gain was improved during the first two wk (241 vs 176 g,  $P<.01$ ) and overall (372 vs 327 g,  $P<.07$ ) for pigs fed carbadox compared with controls. Pigs fed 250 ppm aspirin compared with controls had improved daily gain during wk 3 through 5 (490 vs 436 g,  $P<.10$ ) and tended to be greater overall (363 vs 327 g,  $P=.16$ ). Daily gain of pigs fed higher levels of aspirin were similar to the controls. Although pen means were not statistically different for daily feed intake and feed per gain ratios, they tended to parallel daily gains; pigs which grew faster, ate more and were more efficient.

**DIFFERENTIAL GROWTH RESPONSE OF CORN VARIETIES TO EPTC AND METOLACHLOR.** S. P. Yenne, C. K. Cottingham, and K. K. Hatzios, Dept. of Plant Path., Phys., and Weed Sci., Virginia Polytechnic Institute and State University, Blacksburg VA 24061. Several corn varieties have been discovered that exhibit differential tolerance to the thiocarbamate herbicides, particularly EPTC. EPTC is used to control germinating grass weeds in corn. Another class of herbicides that is also used for this purpose is the chloroacetanilides, alachlor and metolachlor. These two classes of herbicides exhibit similar symptomology and have been shown to inhibit the same metabolic processes such as protein, RNA, DNA and lipid synthesis. Given the similarities between the thiocarbamates and chloroacetanilides, our objective was to determine, at the whole plant level, if the corn varieties that exhibit differential susceptibility to the thiocarbamate, EPTC, also exhibit differential susceptibility to the chloroacetanilide herbicide, metolachlor. Greenhouse experiments demonstrated that the corn varieties also exhibit differential susceptibility to metolachlor, but not to the same level. For example, the fresh shoot weight of DeKalb XL-72AA was inhibited by 21% with 10.1 kg/ha of EPTC and 16% with the same rate of metolachlor, while DeKalb XL-67 was inhibited by 31% with EPTC and 23% with metolachlor.

BIOINSECTICIDES FOR COLORADO POTATO BEETLE CONTROL. Geoffrey Zehnder. Va. Polytechnic Inst. and State Univ., Eastern Shore Agric. Exp. Stn. Painter, VA. 23420. Laboratory and field experiments were conducted to evaluate toxicity and anti-feedant effects of a new strain of Bacillus thuringiensis, var san diego (Btsd), and an extract from the neem tree, Azadirachta indica, against the Colorado potato beetle (CPB). Consumption of potato foliage treated with Btsd resulted in high mortality of small CPB larvae, but large larvae and adults were better able to recover from sub-lethal doses of Btsd. The primary effect of neem on CPB adults exposed to treated potato foliage was one of avoidance or reduced acceptance, whereas the effect on larvae was one of decreased vigor or direct mortality. Field applications of Btsd and neem extract resulted in significant control of CPB populations in potatoes.

## Astronomy, Mathematics, and Physics

THE USE OF LONGITUDE-VELOCITY DIAGRAMS IN THE IDENTIFICATION OF GIANT MOLECULAR CLOUD COMPLEXES IN THE GALAXY. David S. Adler, Dept. of Astronomy & William W. Roberts, Jr., Dept. of Applied Mathematics, Univ. of Va., Charlottesville, Va. 22903. Galactic disks generated from an N-body cloud-particle code are used to investigate the use of longitude-velocity diagrams in the identification of molecular cloud complexes in the Galaxy. Two procedures that parallel methods used for reduction of Galactic data are devised to reduce the level of background clouds and isolate cloud complexes in the l-v diagram. While both procedures succeed in isolating complexes in the l-v plane, neither one succeeds to a great extent in identifying real complexes in the model galactic disk. Associations identified as complexes in the l-v plane are found to be spread out along the entire line of sight in the model disk. These results lead us to conclude that the standard method of identifying molecular cloud complexes in the Galaxy via analysis of the l-v diagram is not reliable. Implications on the conversion of Galactic data to a face-on view of the disk and on the derivation of an integrated mass spectrum are also discussed. (This work was supported in part by NSF under Grants AST-82-04256 and AST-87-12084 and NASA under Grant NAGW-929).

HIGH TEMPERATURE RESISTIVITY OF THE SUPERCONDUCTOR  $\text{YBa}_2\text{Cu}_3\text{O}_x$ , Bruce Almeida\*, R. Caton, R. Selim, and F. Tambone\*; Dept. of Physics, Christopher Newport College, Newport News, VA 23606. We measured the dc resistivity as a function of temperature from 30 to 850C on  $\text{YBa}_2\text{Cu}_3\text{O}_x$  made by the sintering method. Four-probe contact to the sample was made by fusing platinum wires to silver beads bonded directly to the sample. A type-R thermocouple was used to measure the temperature. Measurements were taken while the temperature was increased by .3 degrees per minute in an air environment. The resistivity increased until a sharp, broad peak occurred at approximately 400C followed by a sharp rise in resistance. The samples were also treated in oxygen where we noted an immediate and overall decrease in resistivity both through temperature cycling and as a function of time at fixed temperature. The results from these measurements will be valuable in improving the processing of these important superconducting materials. (Work supported by CSIP of NSF, Grant No.8740149 and NASA Grant NAG-1-796.)



LATEST DEMOS FROM VMI. D. Rae Carpenter, Jr. and Richard B. Minnix, Dept. of Phys., VMI, Lexington, VA 24450. The VMI demonstration workshops held annually since 1973 produce a new round of shared demos each summer. Three given in this paper are a methanol explosion in a 30-litre plastic water bottle, the resonance of fixed-free hacksaw blades of various lengths excited by vibrations from an electric drill operated on a light dimmer, and the cooking of a hot dog with 120-volt AC. For the latter, transparencies are shown of power and resistance vs cooking time. (Summer workshops supported by the National Science Foundation.)

LASER VAPORIZATION OF SOLIDS INTO AN INERT GAS: A MEASURE OF HIGH TEMPERATURE MOLECULAR STABILITY. C.W.S. Conover, Y.A. Yang, and L.A. Bloomfield, Department of Physics, University of Virginia, Charlottesville, Va. 22901. We have studied the effects of an inert cooling gas on laser vaporization of solid sodium chloride. The uncluster decay cascades that follow the vaporizing laser pulse are rapidly quenched in helium or argon gas, generating cluster ions whose relative populations reflect their high temperature stabilities against decay. Cluster production and thermalization are shown to occur in less than 15 nanoseconds. Abundance measurements of  $[\text{Na}(\text{NaCl})_n]^+$  ions ( $n = 1$  to 157) confirm that surface steps are the most stable additions to a cuboid base lattice.

THE PROBLEM OF THE TRAVELING SALESMAN: HEURISTICS BASED ON INSERTION METHODS. Drew Davis, Dept. of Mathematics and Computer Science, James Madison Univ., Harrisonburg, Virginia 22807. Sponsored by Diane M. Sprenger. Preliminary report. The classic problem of the traveling salesman (TSP) is well-known. An important group of heuristics that produces optimal solutions to the TSP consists of insertion approaches. We investigate the nearest-addition algorithm, a well-known insertion approach, with computer implementations of several algorithmic variants that we have proposed. Specifically, six variants are considered: systematic right insertion, systematic left insertion, random insertion, alternating insertion, best insertion (proposed by Dan Estepp), and worst insertion. Based on the performance testing of some 140 arrays, randomly generated, of sizes  $n = 5, 10, 15$ , and 20, we conclude that (1) best insertion yields an optimal tour over 50% of the time, (2) systematic left (and systematic right) insertion yields an optimal tour about 30% of the time, and (3) random, alternating, and worst insertions each yield optimal tours less than 15% of the time. The  $O(n^2)$  behavior of the algorithms is also verified.

VIDEOTAPES IN PHYSICS LABS: an instructional aid. Frederick F. Hartline, & George R Webb, Physics Dept., Christopher Newport College, Newport News, Va. 23606. One time consuming task for the lab instructor is explaining the lab setup, the use of equipment and any additional background information that is relevant to the lab activity. In large lab sections, a demonstration-lecture frequently precedes the lab experience to convey this information, but students may have trouble seeing the demonstration, and often forget crucial steps in complicated procedures. A significant portion of the instructor's time and energy goes to reteaching these materials; consequently less time is available for substantive conceptual questions. Videotaped lab instructions can solve these problems. Videos are easily produced in house. They give complete, repeatable instruction, and allow students to pace themselves. This use of video makes preparation easier for instructors who are unfamiliar with the material and frees up the instructor to handle the students' conceptual problems. Students readily learn to use the medium, and appreciate the independence it gives them to review procedures and move at their own pace. (Supported by the State Council of Higher Education for Virginia)



ON TEACHING THERMONUCLEAR WARFARE FOR THREE YEARS: HUMAN VALUES IN A M.A.D. WORLD. Kenneth C. Jacobs, Dept. of Physics, Box 9661, Hollins College, Roanoke, Va. 24020. During the January Short Term at Hollins College, the author has taught an undergraduate (primarily Freshman) seminar on thermonuclear warfare in three of the last four years: 1985, 1986, and 1988. The philosophy, content, format, and efficacy of the seminar have evolved from those described earlier (K.C. Jacobs, Va.Jour.of Sci. 36, 99, Summer 1985) to more emphasis on the human values inherent in the subject matter. The seminar has retained extensive readings, movies, critiques, and discussions; but these have been supplemented by several guest speakers with intimate knowledge of defense analysis and nuclear warfare. This talk outlines the object lessons which have been learned (sometimes through painful experience) during the past four years; it can be useful to those teaching / or contemplating teaching / a similar course. (Supported in part by the Freshman Short Term Program at Hollins College.)

HIGHER-ORDER TERMS IN THE SERIES EXPRESSIONS FOR CHEMICAL POTENTIAL AND ENERGY OF AN IDEAL FERMI-DIRAC GAS. Edward M. Kiess, Physics Dept., Hampden-Sydney Col., Hampden-Sydney, VA 23943. In a recent publication<sup>1</sup>, the series expressions for chemical potential and energy of an ideal Fermi-Dirac gas were extended to terms in temperature raised to the sixth power. This was done by a new method in which the series were obtained as solutions of differential equations. In this paper, the eighth-power terms are presented.

<sup>1</sup>Am J. Phys. 55, 1006 (1987).

FITTING DATA BY A CONIC SECTION. Maria H. Lam, Dept. of Computer Science, Hampton Univ., Hampton, VA 23668. A conic section can be represented either algebraically or geometrically. In theory, it can be represented algebraically by a quadratic relation of the form

$$ax^2 + 2bxy + cy^2 + 2dx + 2ey + f = 0.$$

It is completely determined by five data points as only five of the six coefficients are independent. These coefficients can be determined by solving a system of five linear equations in six unknowns indirectly. This method is found to be numerically unstable. Its floating point implementation on a computer almost invariably produces perturbations in the coefficients which may alter the character of the conic section. Several sets of conic data are generated. For each data set, five consecutive data points are used for fitting. A rotation is performed to eliminate the mixed term. The coefficients of the result are observed and compared. This process is repeated until all points of a data set is exhausted. Result of this research will be presented. (Supported by NASA under grant NAG-1-760)

SOME TIMELY CLASSROOM EXAMPLES IN APPLIED CALCULUS. Lester N. LaPrade, Dept. of Mathematics and Computer Science, James Madison Univ., Harrisonburg, Virginia 22807. Sponsored by Diane M. Spresser. The first calculus courses are the subject of considerable national interest today, as evidenced by the "Calculus for a New Century" movement. Selected examples in an introductory calculus course for students in business and the life sciences are presented and examined closely to determine the types of errors commonly made by students. The analysis indicates that many students have considerable difficulty with algebraic concepts and skills even though the course has an appropriate algebra mastery prerequisite and it is enforced. Other kinds of errors commonly made by students are also identified. We further present some application problems that reflect the spirit of "Calculus for a New Century" and their solutions.

## AVERAGING OF NONLINEAR WAVETRAINS

J. W. Larson and E. R. Tracy\*, Physics Department, Col. of Wm. and Mary, Williamsburg, Va

Consider a narrow-banded (nearly monochromatic) wavetrain propagating in a weakly nonlinear medium. In such a situation it is desirable to eliminate the rapid carrier oscillations in favor of a reduced equation which describes the dynamics of the wave envelope. This procedure invariably leads to a nonlinear Schrödinger-type equation (NLS), whose canonical form is given by

$$iu_T + u_{XX} \pm 2|u|^2u = 0.$$

This equation is exactly solvable by inverse scattering techniques (IST), a method of solution which relates the wave  $u(X,T)$  to its decomposition in a complete set of nonlinear modes, called the *scattering data*. By examining the NLS limit of another system solvable via IST, namely the Korteweg-de Vries (KdV) equation ( $u_t + 6uu_x + u_{xxx} = 0$ ), we arrive at the simple result that the NLS scattering data is the 'average' of the KdV scattering data. Relationships between the conservation laws of the two systems will also be discussed.

ULTRAVIOLET EMISSION OF A ONE-HERTZ HYPOCYCLOIDAL PINCH DEVICE. S. M. Lee, D. D. Venable, J. H. Lee, and K. S. Han, Dept. of Physics, Hampton University, Hampton, VA 23668. We have developed a 1 Hz hypocycloidal pinch (HCP) system with maximum charging energy of 1.1 kJ and have utilized this system as an ultraviolet (uv) broadband optical pump source for dye lasers. When operating at 630 J with 10 Torr Ar pressure, our HCP has a stored-energy efficiency of 68% and 1.1% of this is converted into optical pump energy. Twenty-four percent of the optical pump energy lies within the absorption band of BBQ, the dye selected for testing the system. Thus, we effectively convert 0.2% of our charging energy into useful pumpband light in the uv region. In this paper we report on the uv emission observed at 1 Hz operation of the system. We also present preliminary results for theoretical modeling of the plasma acceleration. This research is supported in part by Grant AFOSR-86-0345.

SCANNING TUNNELING MICROSCOPY OF TRANSITION METAL DICHALCOGENIDES: ATOMS AND CHARGE DENSITY WAVES AT 4.2 AND 77K. William W. McNairy,

Brian Giambattista\*, C.G. Slough\*, A. Johnson\*, and R.V. Coleman\*, Dept. of Physics, University of Virginia, Charlottesville, Va. 22903. STM studies of atoms and CDWs of TMDs at 77 and 4.2K with atomic resolution of the local density of states (LDOS) near the Fermi energy ( $E_F$ ) are presented. The 1T, 2H, and 4Hb phases of the TMDs offer a wide range of CDW modifications to the LDOS. In general, the 1T phase compounds have a large amplitude CDW with periodicities of 2, 4, and  $\sqrt{13}$  times the atomic lattice spacing,  $a_0$ . The 2H phase compounds have weaker CDW contributions at  $\approx 3a_0$ . The CDW modulations in the 4Hb phase crystals exhibit a combination of the above contributions due to the alternating 1T and 1H layered structure. Preliminary results on the linear chain compound NbSe<sub>3</sub> are also reported with some evidence of the CDW along the chains.

TEMPERATURE DISTRIBUTIONS PRODUCED BY INDUCTIVE HEATING OF INTRACRANIALY IMPLANTED THERMOSEEDS. J.A. Molloy & R.C. Ritter\*, Dept. of Physics, Univ. of Va., Charlottesville, Va., 22901, & E.G. Quate\* & G.T. Gillies\*, Dept. of Nuclear Engineering and Engineering Physics, Univ. of Va., Charlottesville, Va., 22901, & M.S. Grady\* & M.A. Howard\*, Dept. of Neurosurgery, Harborview Med. Ctr., Seattle, Wa., 98104.

A new method of treatment for deep seated brain tumors is being developed in which a small (1/8" diameter) metallic "thermoseed" is inductively heated and remotely rastered throughout the diseased volume, thereby delivering a highly localized hyperthermia treatment. Theoretical predictions of the required power absorption in the seed with resulting thermal distributions have been made and an rf system for delivery of power to the seed has been modeled. Optimization of the frequency range has been chosen to allow maximum power absorption in the seed while keeping direct tissue heating to acceptable levels. Empirical relationships between tissue temperature and treatment time are used in determining treatment methodology, i.e., speed of seed motion and volumetric exposure time.



EXPERIMENTAL NUCLEAR PHYSICS STUDIES WITH PIONIC PROBES. Dinko Počanić, Dept. of Physics and Inst. for Nuclear and Particle Physics, Univ. of Virginia, Charlottesville, VA 22901.

A brief review is given of the current experimental research program in intermediate energy physics with pion beams, which is being carried out by members of the University of Virginia Physics Department. Among the recently completed experiments are: a precise measurement of the charged - neutral pion mass difference, search for the admixture of massive neutrinos in the decay  $\pi^+ \rightarrow \mu^+ + \bar{\nu}$ , search for nucleon clusters in light nuclei using the  $(\pi^+, \pi^+ d)$  reaction, and study of isospin splitting of the  $A = 13$  giant dipole resonance with the  $^{13}\text{C}(\pi^+, \pi^0 p)$  reaction.

Finally, possible future experiments are discussed.

THEORETICAL PREDICTIONS AND EXPERIMENTAL RESULTS FOR A LOW ENERGY ELECTROMAGNETIC PROPULSION SYSTEM. W. Brian Powers\*, and G. R. Taylor, Jr., Dept. of Physics, James Madison University, Harrisonburg, VA 22807. Predictions obtained from two computer models are compared to the experimental results obtained from a low energy electromagnetic propulsion/railgun system. For different system parameters, comparisons are made between the railgun's maximum current values, time of peak currents, and energy efficiencies. Preliminary results indicate that both computer models are accurate in predicting selected experimental results, but neither model accurately predicts all results.

An Improved Analytic Model for Divertor and Scrape-Off in Tokamaks, Alkesh Punjabi and John Georges, Department of Mathematics, Hampton University, Hampton VA 23668. Two Chamber Model of Langer and Singer for the scrape-off and divertor in tokamak is used to study H mode transition. Post's approach for neutral transport is used. Geometric mean flux-limited expression for parallel electron heat conduction is used. Two Chamber Model equations are studied in a catastrophic theory set-up. It is found that experimentally observed features of H mode transition can be explained by catastrophes of the model.

COLD NEUTRONS AT THE UNIVERSITY OF VIRGINIA. Roger L. Ritenour, Robert U. Mulder, Dept. of Nuclear Engineering and Engineering Physics, Univ. of Va., Charlottesville, Va. 22901. Cold neutrons, which are neutrons of low kinetic energy and long wave lengths, are used in many new fields of research. The University of Virginia's Dept. of Nuclear Engineering and Engineering Physics is embarking on an effort to upgrade its nuclear research capabilities by installing a Cold Neutron Source into the university's research reactor. The Cold Neutron Source will be a volume of ice adjacent to the nuclear reactor. Reactor neutrons will enter and interact to reach thermal equilibrium, and hence become "cold" neutrons for a cold neutron beam. The volume of ice will consist of a mixture of heavy and light water and will be cryogenically cooled to 25°K. This project is currently in its design phase where the researchers are performing computer simulations on cold neutron production of various proposed designs. The design phase is anticipated to be completed in 1989 and the construction and installation phase should commence in 1990.



SOME PRELIMINARY EXPERIMENTS WITH HIGH TEMPERATURE SUPERCONDUCTORS. J. D. Rudmin\*, D. G. Meekins\*, R. A. Serway, and G. R. Taylor, Jr., Dept. of Physics, James Madison University, Harrisonburg, VA 22807. The high-temperature superconductor  $Y_1Ba_2Cu_3O_x$ , which has a transition temperature above liquid nitrogen temperature of 77K, was studied using both AC and DC four probe resistance measurements. Experience obtained in preparing  $Y_1Ba_2Cu_3O_x$  samples from raw materials will be reported. Both AC and DC resistance measurements and the Meissner effect demonstrated that the samples were superconductors. Resistance measurements from 295K to 77K on these samples and commercially obtained samples show that the transition temperature is approximately 91K, which is consistent with results reported by others for measurements on samples of  $Y_1Ba_2Cu_3O_x$ .

FORMATION AND EVOLUTION OF DUST-SAND CLOUDS BEHIND MOVING VEHICLES: CLIMATIC AND ENVIRONMENTAL FACTORS William S. Russell & William W. Roberts, Jr., Dept. of Applied Mathematics, Univ. of Va., Charlottesville, Va. 22903. Field Commanders must be able to make quick and accurate decisions. High winds, dusty and sandy environments, and explosions of various kinds are prime examples of factors which determine the extent of the *dirty battlefield*. Possibly the most important factor contributing to this scenario is that due to vehicular generated dust-sand clouds. The dimensions and contents of these clouds, their overall signature, their motion, and the degree of their (infrared and visual) obscuration all play important and sometimes *critical roles*. This work represents a first stage mathematical-computational study directed toward deeper understanding of the formation of dust-sand clouds and their evolution behind and in the vicinity of moving vehicles, such as tanks, in different climatic and environmental conditions. A mathematical model is formulated and a computational code is developed for the purpose of carrying out such studies on the formation and evolution of vehicle-generated dust-sand clouds. (This research was supported by the U.S. Army Engineer Topographic Laboratories under Grant DACA72-87-M0515).

MECHANISMS OF HIGH TEMPERATURE SUPERCONDUCTIVITY. J. Ruvalds, Physics Dept., Univ. of Va., Charlottesville, VA 22901. A review of the properties of  $YBa_2Cu_3O_7$  and other high temperature superconductors is presented with emphasis on relevant explanations of the high transition temperature  $T_c$ . The formation of acoustic plasmon modes is examined, and their possible role in strong electron pairing is discussed.

HIGH RESOLUTION X-RAY SPECTROSCOPY. William C. Sauder, Dept. of Physics and Astronomy, Va. Military Inst., Lexington, VA 24450. Modern techniques of high resolution x-ray spectroscopy depend upon two historical developments: the demonstration of the principle of the double crystal spectrometer by A. H. Compton in 1917, and the availability of dislocation-free crystals since the 1960's. Mechanical stability and the nature of vertical divergence collimation systems are the principal limitations of the double crystal spectrometer as an instrument for studying x-ray line shapes. The monolithic double crystal spectrometer represents another step forward in the evolution of high resolution spectroscopy. Possible applications are considered.

RARE EARTH SUBSTITUTION STUDIES OF THE HIGH TEMPERATURE SUPERCONDUCTOR  $\text{YBa}_2\text{Cu}_3\text{O}_x$ . Raouf Selim, R. Caton, W. Edwards\*, R. Harvey\*, & A. Plum\*, Dept. of Physics, Christopher Newport College, Newport News, VA 23606. Resistance measurements of the high temperature superconducting samples were made using a dc 4-probe technique in the temperature range of 20 - 300K. We developed a fully automated data acquisition system to control the temperature of a closed cycle He refrigerator and to collect data in small temperature steps of  $\sim 1\text{K}$ .  $\text{ABa}_2\text{Cu}_3\text{O}_x$  samples (A= Y, Ho, Dy, Sm, Gd, Tm, Nd, Pr) were prepared from oxide powders using a sintering process. Resistance data indicate that substitutions for Y do not cause a significant change in the superconducting transition temperature. (Work supported by CSIP of NSF, Grant No. 8750149 and NASA Grant NAG-1-796.)

STUDIES OF HIGH- $T_C$  AND HEAVY-FERMION SUPERCONDUCTORS WITH MUON SPIN ROTATION. C.E. Stronach, Physics Dept., Va. State Univ., Petersburg, Va. 23803; W.J. Kossler\*, H.E. Schone\*, J.R. Kempton\* and X.H. Yu\*, Physics Dept., Col. of Wm & Mary, Williamsburg, Va. 23185; Y.J. Uemura\*, Physics Dept., Brookhaven Nat. Lab., Upton, NY 11973; A. Schenck\*, B. Hitti\*, F.N. Gygax\* and S. Barth\*, ETH Zürich, Switzerland; C. Baines\*, Peter Scherer Inst., Villigen, Switzerland; W.F. Lankford, Physics Dept., Geo. Mason Univ., Fairfax, Va. 22030. The muon spin relaxation rate  $\sigma$  has been measured in the high- $T_C$  superconductors  $\text{YBa}_2\text{Cu}_3\text{O}_x$  and  $\text{La}_{1.85}\text{Sr}_{0.15}\text{CuO}_4$  in transverse magnetic fields. The transition temperature  $T_C$ , the magnetic-field penetration depth  $\lambda_L$ , the carrier concentration  $n_s$ , and the effective mass  $m^*$  appear to be connected by the relation  $T_C \propto \sigma \propto 1/\lambda_L^2 \propto n_s/m^*$ . The linear dependence  $T_C \propto n_s/m^*$  suggests a high energy scale for the coupling between superconducting carriers. Oxygen-deficient samples of  $\text{La}_2\text{CuO}_{4-y}$  and  $\text{YBa}_2\text{Cu}_3\text{O}_x$  were found to be antiferromagnetic with Cu magnetic moments significantly less than  $1\mu_B$ . Zero and longitudinal field  $\mu\text{SR}$  on the heavy-fermion superconductor  $\text{CeCu}_{2.1}\text{Si}_2$  show an onset of static magnetic ordering below  $T_C \approx 0.8\text{K}$ . The ordering is either a spin glass or an incommensurate spin-density-wave state. (Supported in part by NASA grant NAG-1-416, NSF grant DMR 8503223 and DOE contract 76-AC02-CA00016.)

PREPARATION AND TESTING OF SUPERCONDUCTING  $\text{YBa}_2\text{Cu}_3\text{O}_x$ . Patrick Taylor and W. T. Joyner, Dept. of Physics, Hampden-Sydney Col., Hampden-Sydney, VA 23943. Samples of  $\text{YBa}_2\text{Cu}_3\text{O}_x$  have been prepared using various pressure and temperature profiles. The transition temperature is found to increase with initial hardness of the sample. The lower the initial room-temperature resistivity of the sample, the higher the transition temperature. Good samples show room-temperature resistivity of a few hundred micro-ohm-cm and transition temperatures between 90 and 100 K. Using a 12 bit A/D converter, three orders of magnitude decrease in resistance can be followed. The experimental set-up uses a 16 channel A/D converter feeding into an IBM XT to read several temperature sensors and the usual four-point probe data. The transition temperature can be raised past 100 K by repeated thermal cycling. Thin layers deposited by an acetone solution method have been found to supercond, but are mechanically fragile. Coating aluminum projectile ring with superconductor at 77 K raises the launch velocity by a factor of six, using our circular-geometry electromagnetic launcher, raising the efficiency of energy conversion into kinetic energy of the projectile from a few percent to nearly 50%.

RESONANT COLLISION SPECTROSCOPY OF Na RYDBERG ATOMS. David S. Thomson, T. F. Gallagher, and R. C. Stoneman, Dept. of Physics, Univ. of Va., Charlottesville Va, 22901. Resonant collisions of the type  $\text{Na } ns + \text{Na } ns - \text{Na } np + \text{Na } (n-1)p$  in which a small electric field is used to tune the levels into resonance were investigated for  $n = 16$  to  $24$ . Transitions to various fine structure components of the p-states, which in previous works were not resolved, were observed. In addition, a numerical solution of a simple model was developed which revealed several interesting properties of the transitions line-shapes. These included a vanishing of the transition probability at exact resonance for certain geometries of the experiment. This feature of the line-shape was observed experimentally.

A PROGRAM TO CALCULATE NUCLIDE PRODUCTION IN THE TARGET OF THE HOLIFIELD ACCELERATOR. Michael E. Thompson and W. Barlow Newbolt, Dept. of Physics and Engineering, Washington and Lee University, Lexington, Va. 24450.

We have used DISSPLA and IMSL routines to produce a FORTRAN program, NUCLID, which will be used for planning experiments at the Holifield Accelerator at Oak Ridge Nat. Lab. The program does three things: 1) it uses the stopping power of the ion in the target to find the range of energies for which the ions are actually in the target, 2) it uses whatever cross section information is available to calculate a macroscopic cross section over the target, and 3) it uses the macroscopic cross section to calculate the production rate of a given nuclide.

STUDY OF ALKALI GRAPHITE INTERCALATION COMPOUNDS USING SOFT X-RAY EMISSION SPECTROSCOPY. S. Velasquez and S.E. Schnatterly, Jesse W. Beams Laboratory of Physics, Univ. of Va., Charlottesville, VA 22901. Graphite and other layered materials exhibit the interesting property that some compounds can be introduced between the layers of the host material. This process is known as intercalation and can greatly change the electronic properties of the host material. The amount of intercalant present is characterized by a staging index  $n$  which indicates the number of adjacent host layers between intercalant layers. The carbon K $\alpha$  emission spectra of stage I and stage II Li, K, and Cs intercalated graphite are presented. These measurements allow the observation of the filling of carbon bands by the electrons from the donor atoms. The newly occupied states appear as an additional peak in the transition density of states (TDOS) of the carbon  $\pi$  band while the  $\sigma$  band remains essentially unchanged. Comparison of the  $\pi$  TDOS for the AGIC's to that of highly ordered pyrolytic graphite enables us to calculate both the amount of charge transfer from the alkali atom to the carbon layers and the chemical shift of the bands caused by the intercalation process. (Supported in part by NSF Grant DMR 8515684.)

THE PRE-LITERATE IATMUL: AN UNUSUAL PERSPECTIVE ON A WAVE MODEL OF MATTER. Jane C. Webb and George R. Webb, Dept. of Physics, Christopher Newport College. 50 Shoe Lane, Newport News, VA 23606.

The role of model in physics is difficult for college students to comprehend, partly because of the level of concreteness at which they operate, and partly because they have had little academic exposure to the concept. This presentation of the modelling activity of a pre-literate New Guinea tribe, the Iatmul, clarifies by the contrasts with a different culture the nature of model-making, and the startling form of the tribal model illuminates one of the important models of our own scientific culture.



**NATURAL SPACE RADIATION EFFECTS ON MATERIALS, DEVICES, AND SYSTEMS.** T.N.Fogarty, V.Zajic, P.M.Kibuule, and C.Lowe, HAMPTON UNIVERSITY, HAMPTON, VA. 23668. Scaling down devices and systems has increased concern for SEU (soft errors) in VLSI. Spice and Crum simulation, and experimental results seem to confirm this. In this paper, the effect of total dose, rate, rebound phenomenon, and secondary radiation effects on materials, devices, and systems will be discussed. The effect of parametric degradation, due to prior total dose radiation, on SEU will be investigated at the new SEFG-SEU facility at BROOKHAVEN. (Supported by the Grants from NASA NAG 5-929)

## Biology

BEHAVIORAL CHARACTER DISPLACEMENT AND INTERFERENCE COMPETITION IN LAND SNAILS. Takahiro Asami, Dept. of Biology, Univ. of Virginia, Charlottesville, Va. 22901.

Mesodon and Triodopsis are conchologically convergent genera in different subfamilies. M. normalis and T. albolabris are very abundant and the largest snails in their respective genera. Mark-recapture experiments in sympatry showed that these mycophagous species share the same microhabitat and that M. normalis is more often found in the daytime than T. albolabris. Laboratory examinations under an artificial light-dark cycle have confirmed that M. normalis is more often active during the light phase than T. albolabris and that allopatric populations of M. normalis are significantly more nocturnal than sympatric populations. Altitudinal variation of the activity pattern did not explain this difference between sympatric and allopatric populations of M. normalis. As the result of a replacement experiment in the laboratory, coexistence of these species without limitation of food reduced the growth rate of M. normalis although there was no detectable effect of intraspecific competition. These results suggest that interference competition has caused behavioral character displacement in the activity pattern of M. normalis and that the activity pattern is largely determined genetically.

AERIAL SEARCHES AND DENNING OF BARRIER ISLAND RED FOXES. Terry L. Bashore\*, Coastal Ecol. Res. Lab., Univ. MD Eastern Shore, Princess Anne, MD 21853 & P. M. Krim\*, Dept. of Biol., Shippensburg St. Univ., Shippensburg, PA 17257. Aerial and ground searches were used to locate red fox (Vulpes vulpes) dens on Maryland's portion of Assateague Island. Sixty-one fox excavations were found during the ground search as compared to two located from the air. Three distinct types of red fox excavations were classified by depth: digs <0.5 m; pseudo-dens 0.5 to 1.0 m; and dens >1.0 m. Foxes "selected" den sites in sandy dunes of shrub succession and Hudsonian habitat at higher frequency than expected. Eighty-three percent of the dens were located in coastal beach soil type and none were found in soils where seasonal water table depth exceeded 0.30 m. Den openings oriented most frequently to the northwest and positively correlated with historically prevailing wind direction. Seventy percent of the dunes containing dens had one den opening and none had more than two.

STATUS AND DISTRIBUTION OF THE LEAST TERN (*STERNA ALBIFRONS*) ON THE VIRGINIA BARRIER ISLANDS. Ruth A. Beck, Department of Biology, College of William and Mary, Williamsburg, VA 23185. J. William Akers, Charlottesville, VA 22901. Jerry W. Via, VPI-SU, Blacksburg VA 24061. Bill Williams, Williamsburg, VA 23185. Small scattered colonies of the least tern, *Sterna albifrons* occur along the beaches of the barrier islands of the Eastern Shore of Virginia. Colonies also occur in Tidewater, Virginia at Grandview Beach in Hampton and at Craney Island in Portsmouth. Survey data has been gathered for eleven consecutive breeding seasons on the geographic locations and population trends of the least tern. A discussion of the survey data and its implications will be presented. Management strategies to protect nesting habitat from development and disruption during the breeding season are recommended for the continued success of least terns in Virginia.

EFFECTS OF FEEDING, TEMPERATURE, AND SHELL MORPH ON LIGHT LEVEL PREFERENCES IN THE LAND SNAIL, *Cepaea nemoralis*. Peter W. Bergstrom & Teresa L. Southard\*, Dept. Biology, Washington & Lee Univ., Lexington, VA 24450. In many habitats, populations of this snail show a positive correlation between shell lightness and maximum light level in that habitat. If this correlation is due to varying thermal properties of the morphs, or climatic selection, then the ability of each morph to choose its optimum climate would be favored. We tested 484 snails from Lexington, VA in a light gradient to see if their choices were consistent with the climatic selection hypothesis. Feeding and temperature were controlled, and both had significant effects on light levels chosen. Snails chose significantly brighter areas when fed than when starved, and when colder compared to warmer, probably to raise their body temperature in both cases. However, we found that the 4 morphs studied (pink banded, pink unbanded, yellow banded, and yellow unbanded) did not differ significantly in light levels chosen. In an earlier experiment, we found that morphs differed significantly in temperatures chosen, and that most of these differences were consistent with the climatic selection hypothesis (darker snails chose cooler temperatures). The results suggest that temperature is more important than light level as a cue for habitat choice in this species. (Supported by grants from Washington & Lee Univ. and VAS.)

FOREST VEGETATION STRUCTURE ON THE EASTERN SHORE OF VIRGINIA CIRCA 18,000 BP. Gordon B. Bonan and Bruce P. Hayden, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903. Pollen records from 18,000 years ago suggest the forests of the Eastern Shore of Virginia were composed primarily of pine and spruce, and to a lesser degree fir and birch. These records have been interpreted as indicative of boreal forest vegetation. A simulation model of modern boreal forest dynamics was used to reconstruct the composition and structure of these forests. The model was parameterized with boreal forest and northern hardwood species from genera observed in the pollen record. Tree species parameters were obtained from known silvics. Climatic parameters were obtained independent of pollen records. At the genus level, the simulated forest composition closely matched the observed pollen records. However, the species dominating the forest (white pine, red spruce, yellow birch, balsam fir) suggested the forest was a transitional northern hardwood-boreal forest not a true boreal forest.

STATUS OF THE PEREGRINE FALCON (FALCO PEREGRINUS) ON THE VIRGINIA BARRIER ISLANDS. Mitchell A. Byrd, Dept. of Biol, Col. of William and Mary, Williamsburg, Va. 23185. The peregrine falcon utilizes the barrier islands extensively during the fall migration period. The species, historically, never nested on the barrier islands although there are two nesting records for Chesapeake Bay. Attempts were begun to introduce peregrine falcons to the barrier islands in 1978. Over 100 birds were released by a technique known as hacking. These releases have resulted in the establishment of seven breeding pairs on the barrier islands. Production of young from these pairs appears adequate to sustain this small population as a permanent component of the barrier islands biota.

NUTRITIONAL RESERVES AND POPULATION STRUCTURE IN OVERWINTERING CARPENTER ANT NESTS. Colleen A. Cannon & Richard D. Fell, Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Carpenter ant nests from infested trees in Montgomery Co., Va. were examined monthly from November, 1987 to April, 1988. Colony composition determinations with respect to life stage and caste/intercaste ratios were based on head capsule measurements obtained via a Filar eyepiece interfaced with an IBM PC. Individual ants were then freeze dried, ground, and analyzed for whole body lipid and carbohydrate content using High Performance Thin Layer Chromatography.

SMALL MAMMAL ASSOCIATIONS ON CHINCOTEAGUE NATIONAL WILDLIFE REFUGE, ASSATEAGUE ISLAND, VIRGINIA. Jack A. Cranford and Mark S. Maly, Biology Dept., Section of Ecology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

To evaluate species-specific variations in habitat utilization by small mammals on Chincoteague National Wildlife Refuge. Live trapping was conducted at quarterly intervals in dune grassland, shrub, woodland and salt marsh habitats. Six species of small mammals were captured: meadow voles (Microtus pennsylvanicus), rice rats (Oryzomys palustris), white-footed mice (Peromyscus leucopus), house mice (Mus musculus), meadow-jumping mice (Zapus hudsonius) and least shrews (Cryptotis parva). Capture sites were characterized with respect to a series of microhabitat variables. Discriminant function analysis was employed to delineate habitat preferences of individual species. Meadow voles tended to occupy microhabitats with principally monocot vegetation and abundant ground cover. Rice rats preferred moist microhabitats and were particularly abundant near tidal creeks. White-footed mice occupied woodland sites and habitats with high shrub cover while house mice were abundant in the shrub-marsh border and in open microhabitats in the dune grassland. Least shrews were abundant in open sites in marsh and dune grassland habitats.

QUANTITATIVE STUDIES OF DAILY AND LIFETIME CHANGES IN HEMOLYMPH TREHALOSE IN COTTON BOLLWORM ADULTS BY HPTLC. Deborah A. Davidson, John L. Eaton\* and Donald E. Mullins\* Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Diurnal and lifetime hemolymph trehalose titers of adult cotton bollworms were examined quantitatively by High Performance Thin Layer Chromatography. Differences were observed within and between days, with daily trehalose peaks occurring near sunset. Flight activity appears correlated with the observed changes.



PREY SPECIES OF BARN OWLS IN NORTHERN VIRGINIA BY PELLET ANALYSIS. Scott R. Deibler, Dept. of Biol., Northern Va. Cmnty. Col., Annandale, Va. 22003. Pellets were collected from six nesting sites of barn owls (Tyto alba) in Prince William County, Va. Sixty one pellets were examined to determine prey species and the numbers of each found. Four species of mammalian prey were identified. Meadow vole (Microtus pennsylvanicus) was the most common prey species, making up 63.1 percent of their total catch. The remaining three prey species were least shrew (Cryptotis parva) 26.0 percent, house mouse (Mus musculus) 5.7 percent, norway rat (Rattus norvegicus) 2.1 percent. The average mean weights of the prey species was taken from literature. These weights were used to determine the average weight of prey that barn owls feed on in Northern Va. The average weight of prey was 21.5g.

A COMPARISON OF STRATEGIES FOR SAMPLING FRESH WATER MUSSELS. Sally D. Dennis, Dept. of Biol., Radford U., Radford, VA 24142, William P. Kovalak\*, U. of Michigan, Dearborn MI & John M. Bates\*, Ecological Consultants Inc. Shawsville, VA, 24162. Different strategies are needed for sampling fresh water mussels depending on the purpose. Qualitative sampling methods available include: hand picking (by wading or diving) and use of mussel bail. Quantitative sampling involves hand picking mussels from a defined area (quadrat). A commercial mussel bail is useful for collecting large numbers of common species for population studies. Quadrat sampling is best for community structure studies. A major problem in sampling is determining sampling effort needed to collect species which are of concern. Neither the bail nor quadrat sampling are efficient in sampling rare species. Since most endangered species occur in low abundance, population studies of such species is difficult. A reasonable approach to monitoring rare species is to characterize the community in which they occur and watch for changes in community structure. In quantitative sampling, critical considerations include size and number of samples taken. Community structure should include a measure of age as well as number of mussel species collected. A comparison of age and length data for many species collected from the same and different populations indicates that age is a more versatile and reliable measure of population structure than length despite the difficulties involved in age determination.

CHOLESTEROL EFFECTS ON THE LABORATORY MOUSE. Julie L. Dietz \* and Franklin F. Flint, Dent. of Biol., Randolph-Macon Woman's Col., Lynchburg, Va. 24503. It is shown that diets supplemented with cholesterol and saturated fats lead to an accumulation of tissue lipids which is greater than in mice fed a fat free diet. It is also shown that the only organ that shows lipid infiltration is the liver. The parenchyma cells exhibit considerable infiltration of lipids which must affect liver function. Control diets exhibit a good contrast in the effects on liver cells.

MAMMALS OF THE VIRGINIA BARRIER ISLANDS. Raymond D. Dueser, Dept. of Environmental Sciences, Univ. of Virginia, Charlottesville, Va. 22903. Twenty-five non-flying terrestrial mammal species have been reported from 17 barrier and marsh islands on the seaward margin of the Delmarva Peninsula. These species include 17 native taxa (opossum, least shrew, short-tailed shrew, eastern cottontail, gray squirrel, Delmarva fox squirrel, marsh rice rat, white-footed mouse, meadow vole, muskrat, meadow jumping mouse, coyote, red fox, raccoon, mink, river otter, and white-tailed deer) and eight introduced species (black-tailed jackrabbit, Norway rat, house mouse, horse, sika deer, cow, sheep, and goat). At least 10 native species on the Peninsula have never been reported on an island. The species found on the islands are thus a subset of the mainland species pool. Species incidence varies from occurrence on one of the surveyed islands to occurrence on 16 islands. Mammalian diversity varies from 0 to 18 species on an island. Four cases of apparent insular extinction and one case of insular subspeciation have been reported.

VIRGINIA COAST RESERVE LONG-TERM ECOLOGICAL RESEARCH PROGRAM. Raymond D. Dueser, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903. The VCR/LTER Program supports long-term environmental research on the barrier-lagoon coastline of the Virginia Eastern Shore. General research topics include (1) patterns and controls of primary production, (2) population distribution and abundance, (3) food chains, (4) organic matter accumulation, (5) nutrient cycling, and (6) disturbance frequency and effects. Both terrestrial and near-shore marine habitats are being studied, with emphasis on islands, bays and marshes. We are concerned with the effects of both short-term, stochastic events (e.g., tropical storms and hurricanes) and long-term, secular environmental changes (e.g., sea-level rise) on the structure and function of this dynamic barrier-lagoon complex. This research is thus designed to provide information on the environmental history of this portion of the mid-Atlantic coastal zone, on its modern functioning, and on its probable response to future regional- or global-scale environmental changes.

THE RARE FLUKE UROTREMATULUM ATTENUATUM MACY, 1933 FROM THE SILVER-HAIRED BAT, LASIONYCTERIS NOCTIVAGANS, IN VIRGINIA. Ralph P. Eckerlin, Nat. Sci. Div., Northern Va. Cmnty. Col., Annandale, VA 22003. The genus Urotrematulum was erected with U. attenuatum the type and only species based on three specimens from the silver-haired bat in Minnesota. Later, Caballero (1942) synonymized Urotrematulum with Urotrema Braun, 1900 without studying any additional material. The only other record is that of Tiekotter (1978) who found two flukes in a Nebraska silver-haired bat. In this study a museum search revealed two U. attenuatum from Cook Co. MN and four from Union Co. OH, all from silver-haired bats. L. noctivagans from VA were surveyed and 1/1 from Fairfax Co. (1 fluke), 1/1 from Westmoreland Co. (53 flukes) and 2/4 from the Dismal Swamp of VA (4 and 5 flukes) were found infected. Both living and preserved specimens had lobed ovaries and testes; well developed seminal receptacle; thin digestive ceca; acetabulum far anterior to the ovary; greatest body width post-equatorial; esophagus long. These are the characters that separate Urotrematulum from Urotrema. Therefore, Urotrematulum is resurrected from synonymy as a valid genus. It is probably not a rare fluke at all, the few records merely reflect the fact that few silver-haired bats have been examined for internal parasites.

EFFECTS OF ISOLATION AND TESTOSTERONE ON SCENT MARKING BEHAVIOR IN MONGOLIAN GERBILS. S. Ward Eisinger\*, Eric P. Skinner\*, & Peter W. Bergstrom, Dept. Biology, Washington & Lee Univ., Lexington, VA 24450. Both male and female adult Mongolian gerbils (Meriones unguiculatus) have a ventral sebaceous gland near the sternum, and sometimes rub it on protruding objects. We studied 13 male and 7 female gerbils to determine whether marking rate varied by sex, and how it was affected by 1) social grouping or 2) testosterone propionate (TP) injections, 500 µg twice weekly, in gerbils with intact gonads. Gerbils were tested 6 times in each of 3 treatments: kept in small single-sex groups, then isolated, and then isolated with TP injections. Males marked significantly more than females ( $P=0.025$ ) when isolated. In male gerbils, both isolation ( $P=0.039$ ) and TP injections ( $P=0.003$ ) caused significant increases in marking rate. However, this marking increase was more pronounced in the 4 young males tested, and thus could be due partly to a natural increase at puberty. In female gerbils, isolation had no significant effect on marking rate, but TP injections caused a significant increase ( $P=0.016$ ). Thus, testosterone levels, and possibly social factors and puberty, affect scent marking behavior in intact Mongolian gerbils.



A COMPARISON OF COLORS, PATTERNS, AND SHELL LENGTHS OVER TIME IN A POPULATION OF THE COQUINA CLAM, DONAX VARIABILIS. Joan Estes & Laura Adamkewicz, Dept. of Biol., George Mason Univ., Fairfax, VA 22030. Samples of D. variabilis were collected once each month during July-October from a site at Virginia Beach. The distribution of shell lengths showed a significant change over time, suggesting that length of the shell is a fair indication of individual growth and population recruitment. This species is also highly polymorphic for shell color and pattern. The umbo of the shell may be colored or not; the shell may display colored rings and/or rays; and the ground color of the shell itself may vary. Like shell length, the frequencies of these elements, particularly of the apparent shell color, also changed over time.

EFFECT OF SALINITY ON THE ULTRASTRUCTURE OF THE AXILLARY ORGANS OF ALGOPHAGUS PENNSYLVANICUS (ACARINA : ALGOPHAGIDAE). Norman J. Fashing, Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23185. A major characteristic of the aquatic mite family Algodhagidae is the presence of axillary organs on each side of the body between legs I and II. The ultrastructure of the axillary organs based on three species implies they are chloride cells and therefore have an osmoregulatory function. The ultrastructure of mosquito anal papillae, a known ion absorbing tissue, can be altered by changing the salinity in which they are reared, and similar results have been found for insect chloride cells. To further elucidate the function of the axillary organs of algophagids, adults of Algodhagus pennsylvanicus, an inhabitant of water-filled treeholes, were exposed for three days to salinities of 0, .25, .5, .75 and 1.0%, and their axillary organs examined for ultrastructural changes. The organs were well developed with extensive plasma membrane plication and numerous mitochondria in mites held in distilled water or low salinity. At .75% salinity, the organs were much reduced with few membrane plications and mitochondria, and at 1.0% the tissue of the organs had atrophied. These results are analogous to those found for insect chloride cells and anal papillae, and help substantiate the probable osmoregulatory function of algophagid axillary organs.

PURIFICATION OF DIPHENOL AND DIQUINONE SCLEROTIZATION AGENTS FROM THE CUTICLE OF THE AMERICAN COCKROACH. David T. Gbadebo, Ross Taylor, T. D. Kimbrough and R. R. Mills, Department of Biology, Virginia Commonwealth University, Richmond, VA. 23284. Acid hydrolysis of hardened cuticle from inter-ecdysial cockroaches was neutralized and chromatographed on a P-2 polyacrylamide gel column. Eluents from the terminal portion of the second peak were applied to an AG-50W X 8 cation exchange resin. Elution with varying concentrations of citrate buffer separated the aromatic diphenols-diquinone fraction from positively charged amino acids and other compounds. These aromatic compounds were further purified on a SM-2 hydrophobic interaction column. Elution with 80% ethyl acetate/20% methanol removed contaminating negative ions and elution with 100% methanol removed the hydrophobic aromatic compounds. After a precise permeation separation on SX-8 poly-vinyl column the purified aromatic components were separated on an hydroxyboryl-cellulose affinity column. Elution with buffer brought down the diquinones while 0.2 M acetic acid removed the diphenols.



GEOGRAPHIC VARIATION IN PERCINA PELTATA (SHIELD DARTER). John T. Goodin and William S. Woolcott, Biology Dept., Univ. of Richmond, Virginia 23173. *Percina peltata* occurs in the drainages of seven Atlantic Coast states from New York to North Carolina. Although regional differentiation has been observed in the species, there has not been a quantitative study to determine the extent of this variation. We analyzed 17 morphological characters on 310 *P. peltata* specimens from throughout its range. Three discernable populations emerged which can be separated on at least the sub-specific level: (1) James drainage northward to the Susquehanna drainage, (2) piedmont and coastal plain Roanoke drainage southward to the Neuse drainage, and (3) montane Roanoke drainage. The populations showed significant ( $\alpha = 0.05$ ) differences in 12 characters, using Duncan's multiple range test. Three of the characters, number of lateral line scales, cheek scales, and scales around the caudal peduncle, were unique to each population. (The study was supported in part by a Univ. of Richmond Undergraduate Research Grant.)

BARRIER ISLANDS AND THEIR ROLE IN THE DISTRIBUTION, VARIABILITY, AND EVOLUTION OF TIGER BEETLES OF THE *CICINDELA DORSALIS* COMPLEX (COLEOPTERA: CICINDELIDAE). James M. Hill, Md. Natural Heritage Prog., Dept. Nat. Res., Annapolis, Md. 21401, & C. Barry Knisley, Dept. Biol., Randolph-Macon College, Ashland, Va. 23005. Tiger beetles of the *C. dorsalis* complex are comprised of four distinct phenotypes separable by size and extent of elytral pigmentation. Barrier islands and other high-energy beaches are the primary habitats within the range of the complex, which extends along the Atlantic and Gulf coasts from Massachusetts to northern Mexico. A complicated clinal variation exists along the entire range of the complex. Previous sea-level and land-mass changes along both coasts had a major impact on the dispersal and evolution of the complex. Barrier islands aid dispersal yet contribute to the variability within and between forms. Separation of the forms was enhanced by the absence of connecting barrier islands between geographic areas, such as along the southern Florida mangrove swamps and across the mouth of the Chesapeake Bay.

CUTICLE FORMATION DURING ECDYSIS BY THE AMERICAN COCKROACH. Saeed A. Jortani, D. T. Gbadebo, T. D. Kimbrough, and R. R. Mills. Department of Biology, Virginia Commonwealth University, Richmond, Virginia 23284. Immature American cockroaches greater than 600 milligrams in total body weight were held at various temperatures. Optimum conditions were found to be 30 day instar periods at 30 degrees C. Apolysis occurred approximately 26 days later. Ecdysis took place from 48 to 60 hours (Mean + 56 hours.) after apolysis. The enzymes tyrosine hydroxylase, dopa-decarboxylase, and N-acetyl-transferase were synthesized de-novo after apolysis. Tyrosine hydroxylase was not activated until the post ecdysial period. Analysis of diphenols or diquinones during the developmental cycle showed that only mono-phenols such as tyrosine were present.

EFFECTS OF SEROTONIN ON THE TRANSPORT OF WATER, AMINO ACIDS AND GLUCOSE ACROSS THE CROP EPITHELIA OF THE AMERICAN COCKROACH. Kanitkar, Parag, Patricia A. Morrisette, T. D. Kimbrough and R. R. Mills, Dept. of Biology, Virginia Commonwealth University, Richmond, VA 23284

The crop epithelia from the American cockroach was clamped between two halves of a dual chamber apparatus. Radiolabelled 14-C-carboxy-inulin was placed on the lumen side and isotope dilution or concentration was used to determine water translocation. Serotonin at 10<sup>-6</sup> M stimulated water movement toward the lumen when crop epithelia from hydrated animals was used. Crop epithelia from dehydrated animals caused water movement toward the blood but serotonin at 10<sup>-6</sup> M had no effect. Both 14-C-tyrosine and glucose were translocated from the lumen to the blood side and the transport was enhanced by serotonin.

BIOLOGY OF LARGE GRAZING MAMMALS ON THE VIRGINIA BARRIER ISLANDS. Ronald R. Keiper\*, Dept. of Biol., Pa. State Univ., Mont Alto, Pa. 17237. Since 1975 data have been collected on the biology of three large grazing mammals on Assateague Island; the native white-tailed deer and the exotic sika deer and feral pony. Fecal analysis in late autumn indicated little dietary overlap between deer and ponies, but considerable overlap between white-tailed and sika deer. This may explain why the number of sika deer is increasing, possibly at the expense of the white-tail. Pony populations have more than doubled since 1975 (45-140 animals). Over an eight-year period, foaling rate was 57.1% and foal survival was 88.3%. In contrast, mortality averaged about 5%. Ponies lived in discrete bands that occupied stable home ranges. They did not defend territories. The number of bands and their size and composition have changed over the course of the study. At low population levels in 1975, there were only 3 harem bands with an average of 14 animals and 5.7 sexually mature mares per band. By 1984, with a population of 110 ponies, 10 harem bands were present and averaged 9 ponies and 3.8 sexually mature mares. At the high population levels of 1988, there were 19 harem bands that averaged only 5.7 animals and 2.7 sexually mature mares per band.

ECOLOGY OF FERAL HOUSE MICE (MUS MUSCULUS) ON WALLOPS ISLAND, VIRGINIA. Gordon L. Kirkland, Jr.\* The Vertebrate Museum, Shippensburg Univ., Shippensburg, PA 17257 and Thomas V. Fleming,\* Dept. of Biol., Univ. of Ala. at Birmingham, Birmingham, AL 35294. The ecology of feral house mice (Mus musculus) was studied on Wallops Island, Accomack Co., Va. during August 1981, March and May 1982, and March 1983. Small mammals were sampled in a variety of habitats: strand, primary dunes, interdunes, secondary dunes, meadows, grass-shrub associations, and woods. The five species collected were Mus musculus, least shrew (Cryptotis parva), white-footed mouse (Peromyscus leucopus), rice rat (Oryzomys palustris), and meadow vole (Microtus pennsylvanicus). Mus musculus was the numerically dominant species, comprising 72.2% of 672 specimens collected during the four sampling periods. There was minimal overlap in the microspatial distributions of Mus musculus and P. leucopus. Mus exhibited a significantly clumped pattern of habitat distribution, evincing a significant preference for primary dunes and not being taken in woods. The overall pattern of habitat preference in Mus musculus on Wallops Island was consistent with a hypothesis that it prefers habitats which resemble natural habitats in which ancestral populations of this species presumably evolved.

DEN SITE CHARACTERISTICS AND FOOD HABITS OF THE RED FOX (VULPES VULPES) ON ASSATEAGUE ISLAND. Patricia M. Krim,\* The Vertebrate Museum, Shippensburg Univ., Shippensburg, PA 17257. An ecological study of den site characteristics, population size, and food habits of the red fox on Assateague Island was undertaken between 20 May and 30 August 1987. Data collected were compared with the results of an earlier study on this species on Assateague Island. Of 96 fox excavations located, 26 were pseudo-dens (6 active, 20 inactive) and 70 were dens (41 active, 29 inactive). Height and width measurements of excavations were significantly smaller in 1987 than in 1985. The excavations were predominantly located in Hudsonia dune and shrub succession habitats (61.5% and 32.3%, respectively) in 1987, whereas in 1985 the respective frequencies were 32.8% and 53.4%. During summer 1987, it was estimated that 11 pairs of red foxes (22 adults) plus an undetermined number of non-breeding adults inhabited Assateague. Fox scat was analyzed in order to determine the major components of the diet of red fox on Assateague. Preliminary results suggest that the cottontail rabbit (Sylvilagus floridanus) and various species of rodents constituted the bulk of prey consumed. Fish, birds, crustaceans, insects, and berries were also consumed in lesser amounts.



IMMUNOGLOBULIN DISTRIBUTIONS IN NORMAL AND RESORBING CBA/J x DBA/2J HYBRID IMPLANTATION SITES IN CBA MICE. J. M. LaSalle and A. F. Conway, Dept. of Biol., Randolph-Macon Col., Ashland, Va. 23005, and C. M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. CBA/J females were injected with Balb/c or DBA/2J spleen cells or left uninjected, then mated with DBA/2J males. Small, medium, and large implants were collected on day 10 after insemination and bisected. Half of each implant was fixed immediately while the other half was washed for one hour prior to fixation. The histological localization and concentration of maternal immunoglobulins G, A, and M were studied using immunoperoxidase techniques. All three immunoglobulins were observed in and around stromal cells of the mesometrial decidua, in cytoplasmic granules of trophoblastic giant cells, in the cytoplasm of spongiotrophoblast cells, and in the apical cytoplasm and on apical surfaces of parietal and visceral yolk sac cells. Washing significantly reduced surface staining of parietal and visceral yolk sac, but increased staining of trophoblastic giant cell granules. Implants from females injected with spleen cells were more intensely stained than implants from uninjected females. Resorptions contained no visible lymphocytic infiltrations and contained very low concentrations of antibodies after washing.

VEGETATIVE DYNAMICS ON THE VIRGINIA COASTAL RESERVE. Gerald F. Levy, Dept. of Biol., Sci., Old Dominion Univ., Norfolk, Va. 23529-0266. Vegetational dynamics on the Virginia Coastal Reserve include a hydric succession progressing on the bay side due to continuing accretion, with ocean side erosion and accompanying salt spray killing strand forest where it exists. On forested dune systems loblolly pine cyclically replaces itself apparently due to edaphic factors. Other cyclic seres also occur. Historical and natural perturbations greatly complicate vegetative interpretation.

ISOLATION OF ENDOCYTIC VESICLES FROM RAT LIVER CELLS BY MAGNETIC AFFINITY CHROMATOGRAPHY. Vivian I. Mah, Larry Volz, Dept. of Biol., Radford Univ., Radford, VA 24142, & Jan Dugan, Dept. of Biochem., Univ. of Florida, Gainesville, FL 32611. The process of pinocytosis includes the fluid-phase pinocytosis and the receptor-mediated endocytosis. Studies have shown that the endocytosed contents are first accumulated in prelysosomal compartments, reprocessed, and eventually delivered to secondary lysosomes. The mechanism by which the endocytic transfer is unknown. The difficulty in elucidating the molecular transfer mechanism is largely due to the fact that classical techniques of subcellular fractionation have not been effective in isolation of endosomes for biochemical analysis. A new approach of isolation of endocytic vesicles by magnetic affinity chromatography has been explored. In this procedure, a ligand (asialoprotein) was conjugated to micromagnetic particles that have either free amino or free carboxyl groups on their surface. After ligand-magnet internalization, the hepatocytes were disrupted and the endocytic vesicles were separated magnetically from all other cell contents. Preliminary biochemical characterization of different populations of endosomes suggests that this novel separation method is endosome-specific, timesaving, and relatively inexpensive. (Supported by a grant from NIH.)

PHYTOPLANKTON ASSEMBLAGES ASSOCIATED WITH THE VIRGINIA BARRIER ISLAND. Harold G. Marshall and Cindy Shomers, Dept. of Biol. Sciences, Old Dominion Univ., Norfolk, VA 23529. Phytoplankton populations are presented for Goose Lake, Smith Island Pond, the inner barrier island channels and waters seaward. The island lake and pond varied significantly seasonally in their salinity with between 9 and 17‰ of their species marine. Different species predominated seasonally in each habitat, with a major development in late winter and early spring dominated by diatoms common to each site. Other major categories included cyanobacteria, chlorophyceans and cryptomonads in summer and fall for the island lake and pond, with dinoflagellates more common at these times in the higher saline waters. High pico-nanoplankton concentrations were common throughout the year at each site.



IMMUNOGLOBULIN A CONCENTRATIONS IN UTERINE FLUID AND IN IMPLANTATION SITES IN CD-1 MICE. L. A. Maxey, M. C. Raynor, and A. F. Conway, Dept. of Biol., Randolph-Macon Col., Ashland, Va. 23005, and J. L. Kilgore and C. M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. A "sandwich" ELISA method was developed to assay IgA concentrations in serum and reproductive tract fluids. The assay gave no detectable positive reaction with IgG or IgM and produced a typical sigmoid dilution curve with purified IgA. However, inhibition of IgA binding in the assay by one or more components in serum and reproductive tract fluids was suggested by variations in dilution curve slopes for these samples. The assay therefore gave reliable relative but not absolute quantitative values. IgA concentrations in estrus stage uterine flushings were similar to serum IgA concentrations. Diestrus stage uterine flushings contained 10 fold lower IgA concentrations than estrus stage flushings. Yolk sac fluid contained IgA concentrations similar to or lower than those in diestrus stage uterine flushings. All reproductive tract fluids tested contained levels of IgA which were above the lower limit of detection of the assay.

PLANT COMMUNITIES OF THE VIRGINIA BARRIER ISLANDS. Cheryl A. McCaffrey \*, P.O. Box 963, Burns, OR 97720 & Raymond D. Dueser, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22903. Vegetation maps have been compiled for 16 barrier and marsh islands on the Virginia Eastern Shore: Metomkin, Cedar, Parramore, Revel, "Crescent," Chimney Pole, Hog, Rogue, Cobb, Little Cobb, Wreck, Ship Shoal, Godwin, Myrtle, Mink and Smith. These maps are based on infrared aerial photographs (1:20000) taken in 1974. Twenty-three distinctive mapping units were identified from botanical and cover characteristics, each representing a plant community, ecotone or non-vegetated area. Most communities exhibit relatively low species diversity, high consistency in species composition and strong dominance. Variation among communities appears to reflect the effects of topography, edaphic factors, exposure, consumer influence, successional age and disturbance history. With periodic resurvey, these maps will be useful for describing site-specific succession pathways on this dynamic, rapidly-changing landscape.

PRELIMINARY VASCULAR FLORA OF THE VIRGINIA BARRIER ISLANDS. Cheryl A. McCaffrey \*, P.O. Box 963, Burns, OR 97720. Vegetation on Metomkin, Cedar, Parramore, Revel, "Crescent," Chimney Pole, Hog, Rogue, Cobb, Little Cobb, Wreck, Ship Shoal, Godwin, Myrtle, Mink and Smith Islands was studied in 1975. Dominant island features included bare, overwashed sand, shrub thickets and pine-hardwood forests, grasslands and salt marshes. Island dynamics were evidenced by accreting dune systems, eroded thickets, and inlet changes. The 222 vascular plant species observed included seven northern outliers and three coastal plain outliers. Several species common on the mainland were uncommon and found only on few islands. Five oak species occurred only on Smith Island, red maple only on Parramore and Smith Islands. Ferns occurred on three islands. Yaupon saplings on Rogue Island were nearly 33 km north of its next southerly occurrence on Smith Island. Human influence is evidenced by six planted and 21 naturalized species. The effect of island dynamics, human use and plant dispersal mechanisms are evident in island species composition.

HERPETOFAUNA OF THE VIRGINIA BARRIER ISLANDS. Joseph C. Mitchell, Dept. of Biology, Univ. of Richmond, VA 23173, & Christopher A. Pague, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23508. Twenty four species of amphibians and reptiles have been reported from the Virginia Barrier Islands, compared to 41 species on mainland Eastern Shore. Assateague, Chincoteague, Parramore, Hog, and Smith Islands contain the highest species diversity, presumably because of various combinations of distance from the mainland, island size, diversity of habitats, and presence of freshwater. Knowledge of the herpetology of the islands is still in the exploration stage; several islands have yet to be surveyed, e.g., Cedar, Ship Shoal, and Wreck. A brief history of exploration and observations on the ecology of several species are presented. Particular attention is paid to the known ecology of the endemic Barrier Islands Rough Green Snake, Opheodrys aestivus conanti. The biogeography of the herpetofauna is discussed relative to island biogeography theory, history, and physiology of selected species.

EFFECTS OF RECEPTOR ANTAGONISM ON SEROTONIN INDUCED MYOPATHIES IN ALBINO MICE. Richard L. Mooney and T.D. Kimbrough, Dept. of Biology, Va. Commonwealth Univ., Richard, VA 23284. Serotonin (5-Hydroxytryptamine; 5-HT) when administered to mice of both sexes at dosages of  $1 \times 10^{-6}$  M reduces contractile effort, causes flaccidity and provokes a state of general debilitation in the skeletal musculature. During a three phase study of 5 days each phase, the  $S_2$ -antagonists, ketanserin (R49945) and ritanserin (R55667) were given to mice which had been pre-treated intraperitoneally with serotonin. During these preliminary experiments, which were conducted without arterial ligation of limb blood vessels, it was determined that not only did the mice show visible signs of recovery from the serotonin induced myopathies but regained skeletal muscle function to values higher than those obtained using untreated mice. The reported values represented contractile responses following electrical stimulation of *in vitro* skeletal muscle preparations which were recorded using a Grass Polygraph System. Mice treated with ketanserin showed contractile activity (in mm) as high as 165% of the control value while those receiving ritanserin showed post treatment contractility of nearly 140% of the control value.

EFFECT OF RADIO TRANSMITTERS ON WILD TURKEY ROOSTING BEHAVIOR. John T. Morgan, Dept. of Fish, and Wildl. Sci., VPI&SU, Blacksburg, Va. 24061, & M. R. Vaughan,\* Va. Coop. Fish and Wildl. Res. Unit, Dept. of Fish. and Wildl. Sci., VPI&SU, Blacksburg, Va. 24061. We assessed the effect of radio transmitters on the roosting behavior of 30 radio-equipped wild turkeys (Meleagris gallopavo) captured during fall 1986 and fall 1987 in the central Piedmont near Buckingham, Virginia. Only 40% (12) of the radio-equipped turkeys flew upon release. Most (8) of these roosted in trees on the night of release and all were found roosting in a tree by the third night after release. Seventy percent (7) of the birds that did not fly upon release (10 of 18 were checked) failed to roost in a tree during the first week after release. Seventeen percent (5) of the 30 radio-equipped turkeys died from predation in the first week. We conclude from these data that radio transmitters may, under some circumstances, have a negative impact on wild turkey survival.

THE INHERITANCE OF CHIRALITY IN AN INTERSPECIFIC CROSS IN PARTULA. James Murray, Dept. of Biol., Univ. of Va., Charlottesville, VA 22901. A cross between the sinistral land snail Partula olympia and the dextral P. mirabilis has shown delayed segregation with dextrality dominant. P. olympia is a member of a ring species in which the terminal entity is P. suturalis, a dimorphic species in which sinistrality is dominant. These results are incompatible with the model proposed by Freeman and Lundelius for the determination of chirality in Lymnaea peregra by two loci with active alleles in the cis position. At least one additional element is necessary to explain the difference in dominance in these closely related species of Partula.



## SEASONAL COMPOSITION OF FINFISH IN WATERS BEHIND THE VIRGINIA BARRIER ISLANDS.

Brenda L. Norcross\*, David Hata\* and John A. Musick\*, Div. Biol. Ocean. & Fish. Sci., Va. Inst. Mar. Sci., Col. Wm. & Mary, Gloucester Point, VA 23062. Bimonthly sampling was conducted in the lagoons and marshes behind Parramore and Cedar Islands at Wachapreague Inlet, and Cobb and Wreck Islands at Sand Shoal Inlet from September 1986 through August 1987. A small mesh bottom trawl was used to concentrate on the use of these areas as a nursery for newly recruited demersal fish. Therefore, pelagic and larger fish, such as tarpon and sharks, are not represented in this study. Eighty-three species of finfish were collected in the 12-month period. Species diversity and abundance fluctuated widely among seasons, with fall being the highest and winter the lowest. The most abundant species over all seasons and all locations were bay anchovy (Anchoa mitchilli) and silversides (Menidia menidia). The most abundant commercially and recreationally important species collected were summer flounder (Paralichthys dentatus) and the Sciaenids, croaker (Micropogonias undulatus), spot (Leiostomus xanthurus) and weakfish (Cynoscion regalis). Adults of these species migrate inward in the spring and leave in the fall, but newly recruited juveniles from at least one of these species were found utilizing these areas almost all year.

INFLUENCE OF TICK SALIVA ON THE REPRODUCTIVE SUCCESS OF MICE. Teresita Ortega, Dept. of Biol., Old Dominion Univ., Norfolk, Va. 23508. Tick infestation of rabbits causes deleterious effects on rabbit reproduction. Pregnancy incidence, litter size and neonatal viability were consistently low in New Zealand rabbits which served as hosts for a Dermacentor variabilis colony. The proportional number of abnormalities found in preimplantation embryos was much higher in tick-exposed rabbits than in the unexposed controls. Also, the presence of ticks seems to have no harmful or stressful effects on rabbit reproduction, thereby suggesting that feeding ticks are causing the adverse effects on the rabbits. Tick saliva has been suspected as a carrier of some unknown anti-fertility substance which can cause a disruption of the pregnancy or initiate embryonic damage. Additionally, it has been observed that rabbits produce antibodies against the ticks' salivary proteins. These observations introduce the implication concerning the reproductive success of other mammalian species. Thus, several methods were used to effectively introduce the unknown salivary component to CD-1 mice, so that their effects on the reproductive success of laboratory mice may be studied.

COMPARATIVE STUDY OF THE EFFECTS OF AGE AND PARITY ON THE MURINE REPRODUCTIVE TRACT. H. Carlton Palmer, Jr., Cherie White\*, John Thombs\*, and Carolyn M. Conway, Dept. of Biology, Va. Commonwealth Univ., Richmond, VA. 23284. The effects of age (3, 5, 8, 12 months) and parity (1st, 2nd, 3rd pregnancy) on reproductive function were studied in CD-1 mice. The number of live births in primiparous females decreased as a function of age. In primiparous females at 12.5 days of gestation, reproductive tract weight, number of implantation sites, % viable embryos, and embryo crown-rump length decreased, while % resorptions increased, as a function of age. In previously pregnant females, parity appeared to counteract some age-related changes. In 5 month old females the number of implantation sites and reproductive tract weight for females in their 2nd pregnancy were higher than for primiparous females. Also the number of implantation sites did not decline as a function of age in multiparous females. These findings indicated that the first pregnancy may have a "priming effect" on the reproductive tract. A higher spleen index (spleen weight/body weight) in pregnant females, as compared to virgin females, suggested pregnancy-related immunological changes. In primiparous females spleen index declined as a function of age and was not affected by parity.



PIPING PLOVER ECOLOGY AND MANAGEMENT. Michael E. Patterson,\* James D. Fraser,\* and Joseph W. Roggenbuck,\* School of Forestry and Wildl. Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. The Atlantic coast piping plover (*Charadrius melodus*) population was listed as threatened under the Endangered Species Act in January 1986 due to declining populations. Part of the decline is attributed to habitat loss from beach development and dune reclamation. Where plovers continue to nest, productivity is often low. Nest predation appears to be the most immediate threat to piping plovers in many areas. While unrestricted recreational activity may be highly detrimental, nesting plovers can apparently habituate to some degree of human activity on beaches. Factors affecting chick mortality are poorly understood. We believe that foraging habitats have a major influence on the distribution and reproductive success of piping plovers on barrier islands. However, these hypotheses need to be tested.

SPATIAL AND TEMPORAL PATTERNS OF ZOOPLANKTON ABUNDANCE IN THE LOWER CHESAPEAKE BAY TRIBUTARIES. Dirk E. Peterson, Ray S. Birdsong, and Ray W. Alden, III. Applied Marine Res. Lab., Old Dominion Univ., Norfolk, VA., 23508. The temporal and spatial patterns of zooplankton abundance from two stations in each of the James, York, and Rappahannock Rivers are reported from monthly samples taken between March 1986 and June 1987. Concomitant phytoplankton samples and water quality data were also obtained. Multivariate cluster and discriminant analyses were used to elucidate spatio-temporal patterns. Three site groups were discriminated by both species composition and water quality. These groups were: 1) tidal freshwater stations of the York and Rappahannock Rivers; 2) riverine/estuarine transition stations of the York and Rappahannock Rivers; and 3) the tidal freshwater and riverine/ estuarine transition stations of the James River. The James River stations differed from those of the other two tributaries most notably in the high contribution of ostracods to the zooplanktonic fauna. Three temporal groups were distinguished: 1) January - May characterized by low zooplankton concentrations, high DO, high silicates; 2) June - August characterized by high zooplankton concentrations (especially *Acartia* and meroplankters), lower DO, higher salinity, high water temperature; and 3) September - December characterized by low zooplankton concentrations and high nutrients.

THE COMBINED EFFECTS OF HYPERTHERMIA AND CHEMOTHERAPEUTIC DRUGS ON MORRIS HEPATOMA 7777 CELLS. T. R. Reilly\* and R. Barra, Dept. of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401-5358. The effects of hyperthermia on the toxicity of Cis-Platinum and Adriamycin, two chemotherapeutic drugs, were studied using Morris hepatoma 7777 cells. In preliminary experiments, drug concentrations of 10 µg/ml were determined to be most effective for this line of hepatoma cells. After treating the cells with the appropriate drug, the temperature of the cells was raised to 42° C and the incubation was continued for 60 or 120 minutes. The percent toxicities were determined and compared to control incubations. The greatest synergistic effects were observed with cis-platinum in which the incubation at 42° C for 60 minutes increased the toxicity level 23%. Hyperthermia also increased the toxicity of adriamycin by 16.7% when the heat treatment lasted 120 minutes. These experiments were performed on cells incubated in media at a pH of 7.4. When the experiments were performed at a pH of 6.8, the toxicity was increased by 14.5% and 22.5% for cis-platinum and adriamycin respectively.

MARINE AMOEBAE IN WATERS OF CHINCOTEAGUE BAY, VIRGINIA: ECOLOGICAL SIGNIFICANCE OF "OLD" AND "NEW" SPECIES. Thomas K. Sawyer, Rescon Assoc., Inc., Royal Oak, Md. 21662 & F.A.R.M.S., Inc., Easton, Md. 21601. Surface waters from Chincoteague Bay, Va., near Franklin City, were sampled for marine amoebae in 1971-72. Seawater cultures yielded 4 new genera and 20 new species in addition to 16 genera and 15 species of previously described amoebae. Among the 16 "older" genera, 6 were described during 1874-1912, 6 during 1921-31, and 4 during 1950-72. The discovery of 20 new species in 1975 indicated that amoebae had not received adequate attention as important components of the marine environment. Several of the "new" species are now recognized as indicators of healthy or stressed coastal environments. Similarly, the "old" genus, Paramoeba Schaudinn, 1896, now includes a species that causes fatal disease in blue crabs; Labyrinthula Cienkowski, 1867, causes a disease of eel grass, and Acanthamoeba Volkonsky, 1931, may cause meningitis or blindness in humans. Coastal waters of Virginia are known to harbor free-living pathogenic amoebae that deserve further ecological study, especially in marshlands and tidal creeks and rivers.

NORTHERN CADDISFLIES IN SOUTHERN APPALACHIAN WETLANDS. Ben M. Stout III, Dept. of Biology, Virginia Polytechnic Institute & State University, Blacksburg, VA, 24061. Pond-dwelling caddisflies (Insecta:Trichoptera) of the families Limnephilidae and Phryganeidae have a mostly northern distribution in North America. Several species were found inhabiting shallow ponds in the Alleghany Highlands of West Virginia. The dominant species (Platycentropus radiatus) is a widely distributed organism, but several of the less prominent species were at or near their southern range limit. Two species had life histories similar to those reported for populations in northern Canada. Perhaps most surprising was the influence of water level on life history and production of the dominant species. Annual production of P. radiatus ranged from 0 to 2.1g dry wt/m<sup>2</sup>/yr. in a series of permanent and temporary ponds, depending on rainfall and pond depth. Field and laboratory experiments revealed close association of some species with certain types of wetlands vegetation. Distribution of these species in the southern Appalachians is restricted to isolated areas having seasonally flooded wetlands, and specific assemblages of submerged vegetation.

SEPARATION OF BIOLOGICALLY ACTIVE CATECHOL COMPOUNDS BY LOW PRESSURE LIQUID CHROMATOGRAPHY. Ross Taylor, D. T. Gbadebo, T. D. Kimbrough and R. R. Mills. Department of Biology, Virginia Commonwealth University, Richmond, VA. 23284. Cuticle hydrolysates from immature American cockroaches and various diphenolic compounds were subjected to low pressure liquid chromatography. Molecular sieving chromatography on P-2 polyacrylamide removed large molecular weight components (greater than 1300 daltons) from naturally occurring cuticle diphenols. Cation exchange chromatography of the cuticle diphenols on AG 50W x 2% (Bio Rad) resolved the sample into two UV (280nm) absorbing peaks. One fraction eluted from the cation exchange with water, and this denotes an acidic or neutral side chain. Another fraction was eluted with 0.2N sodium citrate of elution of aromatic amino acids (tyrosine, dopa and phenylalanine). Chromatography of catechols with acidic sidechains (dihydroxymandelic, dihydroxyphenylacetic) and neutral side chains showed specific elution patterns depending upon the strength or pH of the eluting media. Comparison of elution spectra suggests that various cuticle diphenols may have acidic sidechains after HCl hydrolysis.

REPRODUCTIVE CHARACTERISTICS OF LABORATORY MAINTAINED PEROMYSCUS. C. Richard Terman, Lab. of Endo. & Pop. Ecol., Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23185. Terman and Sassaman (1967, J. Mamm.) reported that significantly ( $P < .001$ ) more males than females were produced in a laboratory colony of Prairie Deermice (Peromyscus maniculatus bairdii) during 1963-64. Recent analysis of the records of our colony of this species has shown that more males than females continue to be produced but only at  $P < .1$ . Further, the average litter size of 5.796 is significantly ( $P < .001$ ) larger than in 1963-64. Our colony of White-footed mice (Peromyscus leucopus noveboracensis) does not produce significantly more males than females, however, the mean litter size of 5.1 is significantly ( $P < .001$ ) larger than at the founding of the colony. Further, the occurrence of reproduction by P. l. n. males captured in nature and paired with females born in the colony is significantly ( $P < .001$ ) greater than of females captured in nature and paired with colony born males. Wild males paired with colony born females sired significantly ( $P < .001$ ) fewer young per liter up to four months after pairing than they did from four to eight months after pairing. (Supported by NSF Grant PCM-8317636 and a Summer and Semester Faculty Research grant from the College of William and Mary.)

DO FUNDAMENTAL PLANT ECOLOGICAL PROCESSES ON THE NORTH CAROLINA OUTER BANKS APPLY TO THE VIRGINIA BARRIER ISLANDS? R. WAYNE TYNDALL. 9933 Campus Way South, Largo, MD 20772. A number of biotic and abiotic factors probably contribute to vegetative zonation along the North Carolina Outer Banks. Seed burial between growing seasons contributes to the rarity of at least one grass zone dominant (Uniola paniculata) and at least one grass and shrub zone dominant (Spartina patens) in the forb zone (beach). Buoyant propagules may be needed by some species to survive burial on the beach between growing seasons. In contrast, the forb zone dominant (Cakile edentula) is uncommon in the grass zone partially because of low soil water potential. The latter contributes to low survival and poor growth by lowering plant water potential and stomatal conductance. Salt spray does not appear to play an important role in segregating forb, grass, and shrub zones due to the primacy of other factors. However, it is important in segregating tree and shrub zones. The underlying cause is probably the absence of tree species along temperate, salt water shores which can maintain the tree habit in the shrub zone. The above factors may have similar roles on the Virginia Barrier Islands. More importantly, however, is the expectation that zonation is the result of spatial and temporal interactions of numerous biotic and abiotic forces.

SEASONAL ZOOPLANKTON PATTERNS IN BACK BAY, VIRGINIA. Bruce Wagoner, Ronald Southwick, and Harold G. Marshall, Dept. of Biol. Sciences, Old Dominion Univ., Norfolk, VA 23529. Surface samples were taken at four stations in Back Bay Virginia to determine micro-zooplankton and net zooplankton assemblages and concentrations from April 1987 to March 1988. A 1000 ml whole-water sample was collected for microzooplankton, and net zooplankton was collected in a one minute tow using a Clarke-Bumpus Plankton Sampler and a #10 net. Dominant microzooplankters included tintinnids and microciliates with a spring peak in early May, and a summer-fall peak ranging from July to September. Cell concentrations ranged from less than  $1.0 \times 10^4$  to  $3.5 \times 10^5$  cells per liter. Highest cell concentrations throughout most of the sampling period were at stations that were less saline. Dominant net zooplankters included copepods and rotifers with highest concentrations in spring. Cladocerans were most abundant during spring and fall. (Supported by the VA Commission of Game and Inland Fisheries).



A LONGITUDINAL SURVEY OF THE BEACH NESTING AND COLONIAL BIRDS OF THE VIRGINIA BARRIER ISLANDS. Bill Williams\*, Williamsburg-James City County Public Schools; Ruth A. Beck, Dept. of Biol., William and Mary, Williamsburg, Va. 23185; Jerry W. Via, Dept. of Biol., VPI&SU, Blacksburg, Va. 24061; & Bill Akers\*, 1492 Shadow Oaks Pl., Charlottesville, Va. 22901. Surveys of beach nesting and colonial birds of the Virginia Barrier Islands from Assawoman Island on the north through Fisherman Island on the south have been conducted during the third week of June since 1975. Data include number of breeding adults, number of nests, nesting stage and substrate, habitat description. Surveys done on foot (occasionally from a boat) with minimum colony disturbance. Consistency in timing, personnel conducting the survey and technique have been stressed. Declining populations on the islands are cattle egret, gull-billed and common tern, black skimmer. With the exception of great black-backed gulls, all other populations appear stable with periodic fluctuations. Three species have begun breeding on the islands since the surveys commenced: white ibis, great black-backed gull, brown pelican. Population trends may be a reflection of island transition, intraspecific competition and/or environmental degradation.

## Botany

THE HIGH-ELEVATION RED OAK COMMUNITY TYPE IN THE MID-APPALACHIANS. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422 and S. L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554. Red Oak (Quercus rubra L.) is often the overwhelming dominant in oak forest communities occurring at higher elevations throughout the southern Appalachians. Quantitative data on structure and composition of vegetation were obtained for red oak-dominated stands at 13 different sites in the Ridge and Valley and Blue Ridge physiographic provinces of western Virginia. All stands occurred at elevations greater than 1100 m (mean elevation = 1229 m) and the majority were situated on slopes with a northern exposure. Red oak had an average importance value of 70.2 in the overstory (stems greater than 9.9 cm DBH) which contained an average of five other species. The most important associates were red maple (average IV = 10.5), black birch (4.2), and white oak (3.8). Mean values for basal area and density of the overstory were 26.1 m<sup>2</sup>/ha and 589 stems/ha, respectively. In the understory (stems 2.5-9.9 cm DBH), red oak was much less important (average IV = 9.8); witch hazel (19.6), red maple (16.2), mountain holly (9.9), and chestnut (8.3) were the other major species present. Detrended correspondence analysis was used to examine site/species relationships among the thirteen stands.

GROWTH-TREND PATTERNS OF RED SPRUCE IN THE OVERSTORY AND UNDERSTORY OF AN OLD-GROWTH STAND IN POCAHONTAS COUNTY, WEST VIRGINIA. H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422 and S. L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554. Increment growth cores were collected from understory (n=16) and overstory (n=19) red spruce (Picea rubens Sarg.) trees in an old-growth stand in Pocahontas County, West Virginia. For understory trees, mean values for diameter at breast height (DBH), tree height, and number of rings were 24.3 cm, 18.6 m, and 157, respectively; corresponding values for overstory trees were 60.3 cm, 31.4 m, and 200. Total radial growth for overstory trees since 1810 (22.7 cm) was nearly twice that of understory trees (11.4 cm) for the same period. Growth-trend patterns for trees in the two different strata were similar during the 1810-1884 (r = 0.877) and 1935-present (r = 0.788) time periods, but were dissimilar during the period 1884-1934 (r = -0.881) when overstory trees grew very rapidly and understory trees either declined or grew rather slowly. Onset of this period of reduced growth in understory trees generally coincides with the late 19th century time period during which extensive mortality of red spruce is known to have occurred in the mountains of central West Virginia. Present rates of growth in both understory and overstory trees are no greater than the lowest values exhibited by these trees at any time during their lifetimes.

CYANOBACTERIA (BLUE GREEN ALGAE) OBSERVATIONS IN THE JAMES RIVER AND LOWER CHESAPEAKE BAY. Lewis F. Affronti and Harold G. Marshall, Dept. of Biol. Sciences, Old Dominion University, Norfolk, VA 23529. Results of the picoplankton component of cyanobacteria composition was presented for stations along a salinity gradient in the James River and Chesapeake Bay. These are ubiquitous cells in these waters with seasonal fluctuations in abundance within the system. Epifluorescent microscopy and the Utermohl procedures were discussed, in addition to their comparisons with results in this study.

SELECTED METHODS FOR THE GROWTH OF SMALL CATTLEYA MERICLONES. Brian Campbell and Martin C. Mathes. Dept. of Biol., Col of William and Mary, Williamsburg, VA 23185. The establishment of small orchid plantlets is critical prior to transplanting into pots and growing under greenhouse conditions. A number of media and hydroponic approaches were explored using uniform meristem plantlets (Cattleya hybrid). Three media (Hydro-Sol: 5-11-26, Orchid. Special: 18-18-18, or Chem-Gro: 10-8-22) were selected and evaluated in a trickle-drip, nutrient flow, intermittent flow or Phototronic growth system. Growth was indicated by increased fresh weight, root growth and foliar appearance. It was concluded that excellent growth was obtained in the trickle-drip system using the Orchid Special medium. Less vigorous growth was obtained using the Hydro-Sol medium and the nutrient flow method.

EFFECTS OF HEAVY METALS ON GREENHOUSE-GROWN PLANTS. B.A. Eiswerth\* and N.M. Milton, U.S. Geological Survey, Reston, VA 22092. Certain heavy metals, when present in the substrate in anomalously high concentrations, have been shown to cause spectral and morphological changes in plants. Our geobotany research group is documenting these changes and developing techniques for using remote sensing observations of metal stress in plants to help support mineral assessment and environmental pollution studies. In the present investigation, greenhouse-grown Hosta ventricosa and Glycine max were dosed with the following metals: Zn, Co, Ni, Cu, Se, and As. Morphological effects of metal presence included lower overall biomass, stunted and discolored roots, and leaves oriented more vertically when compared with the control plants. Spectral reflectance of leaves was measured from 0.4 to 2.5  $\mu\text{m}$  on a laboratory spectrophotometer. Spectral changes observed included a shift in the long-wavelength edge of the chlorophyll absorption band centered at 0.68  $\mu\text{m}$  to a shorter wavelength in the plants stressed with Zn, Co, Ni, and As compounds. The Se-dosed plants, in contrast, exhibited a shift to a longer wavelength compared with control plants, whereas no shift occurred with Cu. These results are consistent with vegetation reflectance anomalies seen in airborne radiometer studies.

EDAPHIC FACTORS AND FOREST VEGETATION IN THE NORTHERN PIEDMONT OF VIRGINIA. John D. Farrell and Stewart Ware, Dept. of Biol., Coll. of William and Mary, Williamsburg, VA 23185. Sampling of overstory ( $\geq 10$  cm dbh) and understory ( $\geq 2.5$  cm  $< 10$  cm dbh) vegetation in 25 old hardwood stands in the northern Va. Piedmont revealed white oak as the most widespread and abundant overstory tree. On a DCA ordination, species were arrayed along an X-axis correlated with soil Ca and Mg in the order chestnut oak, scarlet oak, black oak, northern red oak, and slippery elm. Tuliptree, blackgum, and red maple were all concentrated on the low soil mineral, chestnut oak end of the X-axis, while white ash occurred in the same stands (high Ca, Mg) as slippery elm. Both major hickories (mockernut and Carya ovalis) were concentrated (surprisingly) in stands with higher soil mineral content. The understory had hardly any oaks, many hickory saplings and the same strong mineral gradient as the overstory (blackgum, red maple, and tuliptree at one end, dogwood spread abundantly across the middle, and redbud, ash, and elm at the other end. The right half of the ordination (stands with northern red oak, much hickory, ash and elm) represents vegetational composition not reported by Clark and Ware from the southern Piedmont, where chestnut, scarlet, and white oaks and red maple were the most abundant species.



SEASONAL PATTERNS OF PHYTOPLANKTON COMPOSITION AND CONCENTRATIONS IN THE JAMES RIVER, VIRGINIA. Christine Gregory, J. Lowenthal and H. G. Marshall. Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. In a 16 month study (1986-1987) of the James River a bimodal pattern of summer and late fall development characterized the total phytoplankton, and specifically the cyanobacteria, diatoms, dinoflagellates and cryptomonads. The chlorophyceans had a broad summer-fall expression. Concentrations below the pycnocline were generally greater than above this depth, with the exception of dinoflagellates and cryptomonads. (Supported by the Va. State Water Control Board.)

FLORA OF RICHMOND NATIONAL BATTLEFIELD PARK, VIRGINIA. W. John Hayden, Melanie L. Haskins, Dept. of Biol., Univ. of Richmond, Va. 23173, Miles F. Johnson, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23298, & James M. Gardner\*, Dept. of Biol., Univ. of Richmond, Va. 23173. The vascular flora of nine of the eleven units of Richmond National Battlefield Park was surveyed during the growing season from 1985 to 1987. The sites were visited in two to four week intervals, and plant species were identified and logged in the field and/or collected for later study. A total of 761 different species were identified in the units, and 2487 individual records of species per particular park unit were noted. Twenty-three percent of the flora consists of exotic species, most of which are from Eurasia. The herbaria of the University of Richmond (URV) and Virginia Commonwealth University (VCU) house the voucher specimens. (Research supported by the National Park Service.)

A RAPID AND INEXPENSIVE PENETROMETER FOR MEASURING LEAF TOUGHNESS IN STUDIES OF HERBIVORY. Bruce L. King, Dept. of Biology, Randolph-Macon College, Ashland, VA 23005. Herbivory decreases as leaf toughness increases. Leaf toughness has typically been measured with commercial penetrometers or with devices made by the investigator. There are a number of disadvantages to those described in the literature. I have constructed (and tested) a penetrometer using the following components: aneroid pressure gauge, pressure release valve (from a sphygmomanometer), hypodermic syringe, metal rod affixed to plunger. By replacing the gauge with a pressure transducer it may be possible to convert the device for electronic recording of measurements.

A SEED GERMINATION STUDY OF AUREOLARIA VIRGINICA (L.) PENN. (SCROPHULARIACEAE) Bruce L. King. Seeds of false foxglove (*Aureolaria virginica*) were collected at maturity in early Fall in 1977, 1985, and 1986. The germination requirements and germination percentages were determined. Dormancy is broken by stratification temperatures of ca 5 C. The optimum germination temperature is 20/10 C. Maximum germination percentages were highest for 1985, higher germination percentages were achieved after shorter stratification times, and greater germination temperatures were observed at higher incubation thermoperiods. These differential results may be associated with clearcutting of two of the collection sites.



AN UPDATE OF THE FLORA OF SPRING POND. Mary Lou King, Walter Heeb, III,\* Norlyn L. Bodkin and Emily Baxter, Dept. of Biol., James Madison Univ., Harrisonburg, Va. 22807. Spring Pond, located in the Big Levels area of southeastern Augusta Co., has been noted in past floristic studies by several researchers. These studies identified some unique plants of the Spring Pond area. A complete survey of the vascular flora of the area was attempted during the summer of 1987. The presence of several species mentioned in earlier studies was verified. These include Habenaria clavellata (Michx.) Spreng, Calapogon pulchellus (Salisb.) R. Br., Orontium aquaticum L. and Parnassia asarifolia Vent. Several species found in the area and listed in the Virginia Natural Heritage Program Special Plant List (1987) include Scirpus subterminalis Torrey, Helonias bullata L. and Utricularia geminiscapa. Some species listed in earlier studies were not observed during the 1987 study. Increased visitation of a small, environmentally sensitive area such as Spring Pond will increase the probability of irreversible change in the floristic composition.

SEASONAL PATTERNS OF PHYTOPLANKTON COMPOSITION AND CONCENTRATIONS IN THE YORK RIVER. John Lowenthal, Sean Morrison, and Harold G. Marshall. Dept. of Biol. Science, Old Dominion Univ., Norfolk, Va. 23529. A sixteen month study (1986-1987) of the York River indicated a diverse phytoplankton assemblages of 156 species and a rather stable population base, with the exception of a 1986 spring pulse. Cryptomonads were abundant in summer and fall, with a spring-fall development of diatoms and chlorophyceans. Dinoflagellates had a spring 1987 pulse during this study. Concentrations were generally greater above the pycnocline than below this depth, except for the diatoms and chlorophyceans. Picoplankton concentrations also had a spring 1986 peak. (Supported by the Va. State Water Control Board.)

A STATISTICAL EVALUATION OF SOME ACHENE CHARACTERS FOR SEPARATING HELENIMUM VIRGINICUM BLAKE FROM HELENIMUM AUTUMNALE L. CARL J. MCKAY AND JOHN S. KNOX, Dept. of Biol. Washington and Lee University, Lexington, Va. 24450. Since its description in 1936, the reputedly endemic, Helenium virginicum, has been of uncertain distinction from the variable and widespread Helenium autumnale. Knox (1987) has previously found pappus length to be a useful character in separating H. virginicum and H. autumnale in an experimental garden. This study was designed to test the consistency of pappus length as a statistical parameter in natural populations; and if other seed characters may be used as an accurate source for statistical comparison. Forty achenes were randomly selected and measured from five populations of H. virginicum, two populations of H. autumnale var. canaliculatum, and three populations of H. autumnale var. parviflorum. Statistically significant differences were found between the two species in pappus length. New character differences between the two species were found.

SEASONAL PATTERNS OF PHYTOPLANKTON COMPOSITION AND CONCENTRATIONS IN THE RAPPAHANNOCK RIVER, VIRGINIA. Sean Morrison, Christine Gregory and H.G. Marshall, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23529. Results of a 16 month study in the Rappahannock River indicated a diversified phytoplankton assemblage of 193 species that had major population peaks during late winter and summer. These periods were dominated by a pico-nanoplankton component. Other seasonal patterns of increased abundance were associated with spring (diatoms, dinoflagellates), spring-fall (chlorophyceans), summer-fall (cyanobacteria), with cryptomonads generally abundant throughout the year. Higher phytoplankton concentrations were associated with waters above the pycnocline, rather than below this depth. (Supported by the VA State Water Control Board).

SYSTEMATIC AND EVOLUTIONARY STUDIES IN *BROMUS* (POACEAE, GRASS FAMILY) USING MOLECULAR APPROACHES. Michael Pillay and DR. K. W. Hilu,\* Dept. of Biology, Va. Polytechnic Inst., Blacksburg, VA. 24061. *Bromus*, a genus with over 100 species includes important forage, range and weedy species. The systematics and evolution of the intrageneric components of *Bromus* is highly speculative and inconclusive. Our current understanding of the systematics of *Bromus* is based on comparative morphology and limited cytogenetic studies. Chloroplast DNA restriction endonuclease analysis and prolamin molecular weight data were used to examine existing hypotheses on the systematics and evolution of the *Bromus* complex. Preliminary data from chloroplast DNA and prolamin analysis support part of Stebbins' (1981) scheme but also suggest an alternative hypothesis. The prolamin data seem to support the chloroplast analysis in some respects.  
(Supported in part by Sigma Xi Grants-in-Aid- of Research)

THE VASCULAR FLORA OF THE JAMES RIVER GORGE WATERSHED IN THE CENTRAL BLUE RIDGE MOUNTAINS OF VIRGINIA. Dr. Gwynn W. Ramsey, Curator of the Herbarium, Lynchburg College, Lynchburg, VA, 24501, Charles H. Leys\*, Old Dominion Box, Inc., Lynchburg, VA 24501, Robert A.S. Wright, Director, Central Virginia Biological Research Consortium, Richmond, VA 23225. A decade of study reveals that the vascular flora of the James River Gorge Watershed between Snowden and Glasgow, Va., including the James River Face Wilderness and portions of Amherst, Bedford and Rockbridge Counties, is superbly diverse. Herbarium voucher specimens document that the hydrological systems composing the 3585 hectare research area supports a vascular flora of at least 113 plant families and 313 genera with 671 taxa at the specific or infraspecific level. The largest plant families are: Asteraceae, 89 species; Fabaceae, 38 species; Poaceae, 36 species; Rosaceae, 26 species; Brassicaceae, 26 species; Lamiaceae 24 species; Cyperaceae, 16 species. Ground-level and aerial color slides will be used to show the physiological features, geological formations, disturbances, habitat types and unique plants.

A BIOASSAY TO MEASURE ALLELOPATHIC EFFECTS ON COTTON. Michael H. Renfro\*, Walter Heeb III\*, and Wendelyn T. Renfro\*, Dept. of Biology, James Madison Univ., Harrisonburg, VA 22807. An *in vitro* bioassay has been developed to assess allelopathic interactions of cotton with other plants. The bioassay quantitatively measures stimulation or inhibition of growth of hypocotyl sections relative to controls. Various tissue culture media supplemented with naphthaleneacetic acid and benzyladenine were tested to determine which medium supported best growth of hypocotyl sections. Analysis of explant growth revealed that effects were demonstrable within three weeks. The bioassay was evaluated with plant extracts and known allelochemicals. Seven allelochemicals representing three chemical classes were incorporated into the bioassay medium at 50, 100, 250, 500 and 1000  $\mu$ M concentrations. All chemicals were inhibitory to cotton growth at higher concentrations, but were either inhibitory or slightly stimulatory at the lowest concentrations. Aqueous extracts of five common weeds that are serious agronomic pests were prepared and incorporated into the bioassay medium at 0.05, 0.1, 0.5 and 1% (w/v). Higher concentrations of extract caused growth inhibition. The bioassay provides a sensitive indicator for assessing potential allelopathic reductions of cotton growth.



THE INFLUENCE OF SIMULATED ACID RAIN ON THE GROWTH OF CUCUMBER SEEDLINGS AND EXCISED ROOTS. Jay Sailer and Martin C. Mathes. Dept. of Biol., Col. of William & Mary, Williamsburg, VA 23185. The influence of simulated acid rain is difficult to assess using natural systems. In vitro and hydroponic systems were developed to study the influence of acid conditions (pH 2.8, 3.8, 4.8, and 5.8) in the medium or on the foliar surface. Cucumber seedlings were grown in a hydroponic system with acidified medium and exposed to simulated acid rain misting. Excised cucumber roots were propagated in vitro in acidified medium and in the presence of aluminum, copper, lead and zinc ions at selected concentrations. Cucumber seeds were soaked in simulated acid rain solutions containing heavy metal ions to explore influences on germination and subsequent seedling development. In general, shoot and root growth was inhibited in the presence of high acidity (pH 2.8) and root growth was inhibited in the presence of certain heavy metal ions. These techniques proved useful innovations for the study of root growth responses under acid conditions.

DO SIMILAR FORESTS REGENERATE ON SIMILAR SITES? A NATURALLY REPLICATED EXPERIMENT. Paula M. Schiffman, Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. According to ecological theory, environmentally similar sites support structurally and compositionally similar vegetation. Several researchers, however, suggest that differing plant communities can develop on apparently similar sites. These differences are frequently attributed to stochastic processes. To test this hypothesis, a naturally replicated experiment has been undertaken on Brush Mountain (Montgomery Co., Va.). The Brush Mountain sites, which are characterized by a high degree of environmental similarity (topography, microclimate, soil, disturbance history;  $\alpha=0.05$ ), supported vegetation with measurably similar species densities, frequencies, and covers. Moreover, one year following a disturbance (removal of canopy cover from each site), developing vegetation exhibits generally similar species densities and frequencies. Still, the virtual absence of a soil seed bank suggests that stochastic seed dispersal events have the potential to significantly alter the direction of succession at one or more of the sites.

PHYTOPLANKTON ASSEMBLAGES OF A SALTMARSH - OWL'S CREEK, VIRGINIA BEACH, VIRGINIA. Seba B. Sheavly, Virginia Marine Science Museum, 717 General Booth Blvd., Virginia Beach, VA. 23451. The Virginia Marine Science Museum is located along Owl's Creek which is bordered by high salinity marshes. Owl's Creek flows into the Rudee Inlet basin which opens into the Atlantic Ocean. The water quality of the locale is of grave importance to the museum as the water from Owl's Creek is the primary source of water for the 100,000 gallons of aquaria in the facility. A monitoring project was established in October 1987 to create a data base on the phytoplankton composition of Owl's Creek. Water samples were collected bi-weekly at the upper and lower 0.5m depths in replicate form. Salinity, temperature, dissolved oxygen, and pH levels were recorded along with tidal information and weather conditions. The preliminary results have shown a dominance in the assemblages by diatoms and dinoflagellates where 38 species of diatoms and 18 species of phytoflagellates have been identified.

SEASONAL PHYTOPLANKTON PATTERNS IN THE LOWER CHESAPEAKE BAY. Cindy Shomers, B. Wagoner, L. Affronti and H.G. Marshall, Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23529. Seasonal distribution patterns are presented for a 16 month study (1986-1987) in the lower Chesapeake Bay. A major development occurred in spring for the total phytoplankton and specifically for diatoms, coccolithophores and the pico-nanoplankton. Spring and fall abundance were associated with cryptomonads and dinoflagellates. High summer growth was characteristic for cyanobacteria, chlorophyceans and silicoflagellates. Although total abundance was greater below the pycnocline than above this depth, the cryptomonads, euglenoids, dinoflagellates and cyanobacteria were more common in the upper waters. (Supported by the VA State Water Control



EFFECTS OF A TOPICAL DISINFESTANT AND SELECTED FUNGICIDES ON THE GERMINATION OF AMERICAN ELM (*ULMUS AMERICANA*) SEEDS. F. D. Smith and R. J. Stipes, Dept. Plant Pathol., Physiol. and Weed Sci., Virginia Tech, Blacksburg, VA 24061.

The effects of a topical disinfectant (Roccal=dimethylbenzylammonium chloride) and three fungicides (RH-3486, chlorothalonil and thiabendazole) on the germination of *Ulmus americana* seeds were tested at concns of 10,000 to 0.1  $\mu\text{g/ml}$  at  $\log_{10}$  intervals. Seeds were moistened with solutions and allowed to germinate. Germination was 40% in the water treatment, and only thiabendazole at 10,000  $\mu\text{g/ml}$  depressed germination (to 1%). Root lengths (mm) were noted after 10 days; while those in the water treatment measured 21.7, those treated with 1,000 and 10,000  $\mu\text{g/ml}$ , respectively, of the following compounds yielded these measurements: 14.3 and 12.7 for chlorothalonil, 8.0 and 4.2 for RH-3486, 8.6 and 7.9 for Roccal and 17.6 and 1.0 for thiabendazole. RH-3486 at 10,000  $\mu\text{g/ml}$  triggered precocious true leaf development. No compound freed the seedlings of saprophytic fungi upon transfer to agar media. This study suggests that Roccal and RH-3486 may be sufficiently sub-phytotoxic to evaluate further in planta for the control of elm diseases.

A COMPARATIVE ECOLOGICAL STUDY OF SPRUCE-FIR FORESTS IN THREE DIFFERENT REGIONS OF THE WORLD. S. L. Stephenson, Dept. of Biology, Fairmont State Col., Fairmont, WV 26554, H. S. Adams, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, and L. S. Chauhan, Dept. of Biosciences, Himachal Pradesh Univ., Shimla (H.P.), India. Increment growth cores were collected in the United States from Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) in the Swan Mountains of northwestern Montana, red spruce (*P. rubens*) and Fraser fir (*A. fraseri*) in the southern Appalachians of Virginia, Tennessee, and North Carolina, and Himalayan spruce (*P. smithiana*) and silver fir (*A. pindrow*) in the Himalayan Mountains of northwestern India. In addition, quantitative data were obtained for composition and structure of the vegetation and for chemical and physical characteristics of soils associated with each study site. Mean ages  $\pm$  SE of cored trees ranged from  $96 \pm 6.5$  to  $220 \pm 13.3$  for the three species of spruce and from  $102 \pm 4.7$  to  $132 \pm 8.5$  for the three species of fir. Total radial growth for the period 1900-79 was quite similar (ranging from 9.7 to 12.8 cm) for the three species of fir, but varied considerably for the three species of spruce (11.0 to 21.8 cm). The highest values for both spruce and fir were recorded for the study site in northwestern India. Radial growth for the period 1960-79 exhibited a growth-trend decline for spruce and fir only in the southern Appalachians. (Supported by a grant from the National Geographic Society.)

IN VITRO FUNGITOXIC EFFECTS OF FUNGITOXICANT COMBINATIONS ON THE DUTCH ELM DISEASE PATHOGEN, *OPHIOSTOMA* (*CERATOCYSTIS*) *ULMI*. R. J. Stipes and Jean L. Ratliff, Dept. Plant Pathol., Physiol. and Weed Science, Virginia Tech, Blacksburg, VA 24061.

A number of fungitoxicants, with different modes of action, are active in vitro against the Dutch elm disease fungus, *Ophiostoma* (*Ceratocystis*) *ulmi*. We hypothesized that, by combining different fungitoxicants and therefore invoking more modes of action, we could achieve synergistic fungitoxic activity against the pathogen. We determined the MICs (minimal inhibitory concentrations) of: two ergosterol biosynthesis inhibitors, fenpropimorph (0.1  $\mu\text{g/ml}$ ) and prochloraz (0.1  $\mu\text{g/ml}$ ); one respiration inhibitor, chlorothalonil (0.1  $\mu\text{g/ml}$ ); and one mitosis inhibitor, thiabendazole hypophosphite (0.3  $\mu\text{g/ml}$ ). After pairing these fungicides at 0.5 MIC each in all combinations and observing the effects on fungal germination and mycelial growth, we found no synergistic action. It is possible, however, that synergism may occur in planta, and this remains to be assayed.

FIRST REPORTED OCCURRENCE OF DUTCH ELM DISEASE IN SIBERIAN ELM (ULMUS PUMILA) IN VIRGINIA AT WINCHESTER. R. J. Stipes and K. S. Yoder, Dept. Plant Pathol., Physiol. and Weed Science, Virginia Tech, Blacksburg and Winchester, VA.

The Dutch elm disease (DED) fungus, Ophiostoma (Ceratocystis) ulmi, has been isolated and positively identified from necropsy outer xylem tissues taken from dying Siberian elm (Ulmus pumila) at Winchester, Virginia. The disease was discovered by the junior author. To our knowledge, this is the first report of this disease in this species in Virginia, although it was found in The Netherlands in 1936. The strain of the pathogen was identical morphologically to those isolated routinely from the many dying American elms (U. americana) in the U.S.A., including Virginia. Inoculation tests are being conducted during the current (1988) summer to confirm the pathogenicity of the strain to both U. pumila and U. americana.

ADAPTIVE SIGNIFICANCE OF RAY FLORETS IN ASTERACEAE. Gail S. Taber and Gustav W. Hall, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23186. Research has indicated that showy ray corollas in some members of the Asteraceae are instrumental in attracting pollinators to disc florets. This relationship is being studied quantitatively and experimentally in two genera, Bidens and Senecio, which contain both radiate and naturally discoid species. A large population of B. aristosa (Tickseed sunflower) was divided into three groups: the control group consisted of plants with radiate heads, while the second group had the ray florets removed. A third group was bagged to prevent insect visitation. All groups were intermixed in the population. Insect visitation frequency was observed in the first two groups, and achenes were subsequently scored to determine seedset. The study continues this spring and summer, utilizing the Ragworts S. aureus, S. smallei, and S. vulgaris.

A PRELIMINARY STUDY OF THE VASCULAR FLORA OF HIGHLAND COUNTY, VIRGINIA. Theresa A. Theodose and Gustav W. Hall, Department of Biology, Col. of William and Mary, Williamsburg, Va. 23186. Highland County is located in extreme northwest Virginia, and the area of study consists of approximately 40 square miles in its northwest section. The county is characterized by sandstone ridges, shale and limestone valleys, with igneous volcanic rocks in scattered locations. The study area lies along the West Virginia border with a range of elevation between 2300 and 4300 feet. Habitats represented include oak-hickory forests, beech-maple forests, sphagnum bogs, and some of the few native red spruce stands in Virginia. Although some floristic work has been done in the county, a comprehensive floristic study is lacking. It is the goal of the present study to document plant species not currently listed as occurring in Highland County.

REDISCOVERY OF THE "MOST CELEBRATED COLONY" OF THE SMALL WHORLED POGONIA, ISOTRIA MEDEOLOIDES (ORCHIDACEAE). Donna M. E. Ware, Dept. of Biology, Col. of William and Mary, Williamsburg, VA. 23185. Since its discovery in 1920, Grimes' station for I. medeoloides in James City Co., Va., the first known south of PA, has been visited by numerous botanists and cited in several publications. Carlyle Luer termed it the species' "most celebrated colony". Knowledge of its exact location was apparently lost upon the death of J. T. Baldwin in 1974. My attempts to relocate it began in 1978, and with the aid of information from Fred Case of Saginaw, MI, succeeded in 1986. Ten plants were found scattered over 5 acres. Grimes had found 15 plants over 10 acres in the '20s. He described the forest then as chiefly of white oak, beech, tulip poplar, and chestnut, with a few loblolly pines, many flowering dogwoods, and sparse undergrowth. The tract was selectively timbered soon after World War II. Today, the overstory species of highest relative importance value are white oak (28.2), tulip poplar (13.8), sweetgum (13.0), American beech (8.4), and black oak (6.2). Ground coverage averaged 18.6% (based on 9 m<sup>2</sup> quadrats each centered on an Isotria).

SOIL MINERAL CONTENT AND PLANT SPECIES ABUNDANCE: CHICKEN VS. EGG? Stewart Ware, Dept. of Biol., Coll. of William and Mary, Williamsburg, VA 23185. Statistical correlation between the abundance of a species and the level of an environmental variable tells us nothing about cause and effect; it tells us only that a pattern exists. Nevertheless, we can reasonably assume that in correlations between species abundance and soil moisture or soil texture, the latter are causes of species abundance rather than effects. This reasoning has traditionally been extended to soil mineral content also. It has recently been proposed by Muller and McComb in Kentucky that tuliptree and dogwood increase soil mineral content (through base accumulation in their leaves and rapid decay of their leaf litter). If such soil modification is rapid and widespread, it presents a serious chicken vs. egg dilemma for ecologists trying to determine causes of species abundance: which came first, the soil variable or the species abundance? An examination of data from the Piedmont of Pennsylvania (two studies) and Virginia (two studies) and a re-examination of Muller and McComb's data provide no convincing evidence that stands with high abundance of tuliptree or dogwood are more likely to have high mineral content than stands lacking these species. This is true even when the trees were very large (old?) and have had a long time to influence the soil mineral content.

DEMOGRAPHY OF SEEDLING POPULATIONS OF TABLE MOUNTAIN PINE. Charles E. Williams, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Recruitment of seedlings of table mountain pine (TMP) (Pinus pungens), a fire-adapted species, is essential for population maintenance under low fire regimes. I examined establishment and demography of TMP seedlings in natural populations and in seeded plots in which the effects of 1) canopy type (pine, oak), 2) substrate (litter removed or intact) and 3) predation were evaluated. Summer establishment in seeded plots was low (< 2%) and concentrated in litter removal treatments. Canopy and predation had no effect upon establishment. Mortality in seeded plots was complete: no seedlings survived the summer. Emergence of seedlings from seeded plots during the following spring indicates that TMP is capable of forming temporary soil seed pools and so escape potentially unfavorable growing conditions. Summer mortality in natural populations was highest in young seedlings. Seedlings which survived the summer, however, experienced low mortality in fall and winter.



WEEDY TAXA NEW OR RECONFIRMED FROM VIRGINIA. Robert A. S. Wright, Central Virginia Biological Research Consortium, 5204 Riverside Drive, Richmond, Virginia 23225.

Specimens of several weedy taxa recently collected in the Commonwealth that have not heretofore been reported as occurring here have been deposited in state and national herbaria. Featured in this presentation are the locations and a description of the vegetation at each station. Conjectures are also offered as to the possible origins and the degree of persistence for each of the following species new to Virginia: Fatoua villosa (Thunberg) Nakai; Cassia occidentalis Linnaeus, Euphorbia mercurialina Michaux, Moricandia arvensis (L.) DeCandolle, Silphium lacinatedum Linnaeus and Lesquerella gordonii (Gray) Watson.

THE HISTORICAL FLORISTICS AND ECOLOGY OF LEA'S MEADOW AND THE CLOPTON BOG IN RICHMOND, VIRGINIA. Robert A. S. Wright, Central Virginia Biological Research Consortium, 5204 Riverside Drive, Richmond, Virginia 23225.

Alas, another very interesting and unique wetland habitat supporting a number of local Virginia species has been lost forever. As a result of economic pressure in 1953 to expand industrial warehousing and railroad access at a South Richmond box manufacturing plant, this sphagnous seep, historically known as the Clopton Bog and more recently called Lea's Meadow, was completely drained and filled, thus condemning the area and its associated bog species to certain death. This presentation, through the use of color slides, diagrams and maps, both describes the extirpated vegetation of the meadow and associated pinewoods as well as the past and current edaphic conditions and land uses in the general area.

INTERESTING AND PROBLEMATIC PLANT TAXA COLLECTED ALONG THE JAMES RIVER DRAINAGE IN THE CITY OF RICHMOND, VIRGINIA. Robert A. S. Wright, Central Virginia Biological Research Consortium, 5204 Riverside Drive, Richmond, VA. 23225

Since 1985, the author has been engaged in a floristic and ecological study of the James River drainage through Richmond, Virginia. To date, some 825 taxa have been accounted for in the thirteen-mile research corridor which extends eastwardly above the Fall Zone near Boshers' Dam, through the city, and thence to the mouth of Falling Creek in the coastal plain just east of Deepwater Terminal. The flora of the drainage is remarkably diverse considering the overwhelming amount of development and the conspicuous lack of stable plant communities. Featured in this presentation are the interesting flora elements found thus far in the study. A number of distributional oddities appear and an effort is made to explain their presence. It is speculated that these unexpected taxa represent populations recently introduced from the west by flood events. Other strange elements appear as adventive or are naturalized along several well-travelled motor vehicle, boat and railroad transport routes.

## Chemistry

$\beta$ -CYCLODEXTRIN COMPLEXES OF DIAZIRINES AND DIAZO COMPOUNDS: FORMATION AND REACTIONS. Christopher J. Abelt, Mari B. Mellis, and Jennifer M. Pleier, Dept. of Chem., The College of William and Mary in VA, Williamsburg, VA 23185. Several diazirines and diazo compounds form stable solid complexes with  $\beta$ -cyclodextrin. Pyrolysis or photolysis of these complexes result in degradation of the labile guest. The extractable, volatile products show that the host matrix exerts "reaction vessel" and shape selective effects. The structures of the derivatized cyclodextrin products indicate that the formal carbene insertion reaction is regioselective.

DESIGN AND SYNTHESIS OF N,N-DIETHYL CARBAMAZINE (DEC) ANALOGS AS POTENTIAL INHIBITORS OF LEUKOTRIENE BIOSYNTHESIS. L. T. Alty, Joseph F. Rowe, III, S. C. Hall, M. C. Sackett, S. T. Allen, R. E. Martin, D. N. Tortorelli, Dept. of Chem., Washington & Lee Univ., Lexington, VA 24450, & J. F. Stubbins, Dept. of Med. Chem., Va. Commonwealth Univ., Richmond, VA 23298. Structural analogs of DEC (N,N-Diethyl-4-methyl-1-piperazinecarboxamide), a known inhibitor of leukotriene A<sub>4</sub> (LTA<sub>4</sub>) synthase, were synthesized to determine the structural components necessary for inhibition. The testing of these analogs should reveal the importance of each nitrogen atom, the piperazine ring, the carbonyl oxygen and the two ethyl groups in DEC to its activity as a LTA<sub>4</sub> synthase inhibitor. A potent inhibitor of the leukotriene synthesis pathway would have potential uses in treating asthma, rheumatoid arthritis, and inflammatory bowel disease.

NEW LOWER OXIDES OF PHOSPHORUS AND ARSENIC. Lester Andrews, Robert Withnall and Zofia Miekle, Dept. of Chem., Univ. of Virginia, Charlottesville, VA 22901. Oxygen atoms (<sup>16</sup>O and <sup>18</sup>O) were reacted with P<sub>4</sub> molecules using ozone photolysis and discharge of oxygen as sources, and the products were trapped in solid argon at 12K. The major product P<sub>4</sub>O exhibited a strong terminal P=O stretching mode at 1241 cm<sup>-1</sup>, a P-P=O deformation mode at 243 cm<sup>-1</sup>, and four P-P stretching modes near P<sub>4</sub> values, all of which characterize a C<sub>3v</sub> species. Two new molecular species probably arise from energized P<sub>4</sub>O before relaxation by the matrix: the first absorbed at 1197 cm<sup>-1</sup>, photolysed with red light, and is probably P<sub>2</sub>O; the second absorbed at 856 and 553 cm<sup>-1</sup>, increased with short wavelength radiation, and is most likely due to the C<sub>2v</sub> bridge-bonded P<sub>4</sub>O structural isomer. Arsenic gives similar species with the addition of isosceles triangular As<sub>2</sub>O. The matrix efficiently quenched the large exothermicity (130 ± 10 kcal/mole) for the P<sub>4</sub> + O reaction and allowed the lowest oxide of phosphorus P<sub>4</sub>O to be trapped for the first time as a molecular species.

SOLUTION SPECTROSCOPIC INVESTIGATION OF DIOXOMOLYBDENUM COORDINATION COMPLEXES CONTAINING TRIDENTATE SCHIFF BASE LIGANDS - POTENTIAL MODELS FOR THE OXOMOLYBDOENZYMES. John O. Bachert, III\* and Joseph Topich, Department of Chemistry, Va. Commonwealth Univ., Richmond, VA 23284. Solution spectroscopic data have been acquired for the following dioxo-Mo(VI) complexes containing tridentate Schiff base ligation, (5-X-SSE, SSP, SAP, SAE)Mo(VI)O<sub>2</sub>, where, SSE = [N-(5-X-salicylidene)-2-aminoethanethiolato], SSP = [N-(5-X-salicylidene)-2-aminobenzenethiolato], SAP = [N-(5-X-salicylidene)-2-aminophenolato], SAE = [N-(5-X-salicylidene)-2-aminoethanolato]. It is known that the SSP and SSE complexes undergo oxygen atom transfer reactions with PETPh<sub>2</sub> in DMF. Vibrational spectroscopic evidence indicates that for the Mo complexes that do react, the asymmetric Mo=O stretching vibration does not exceed 902 cm<sup>-1</sup>, whereas for those complexes which do not react, no Mo=O stretching vibration appears below 906 cm<sup>-1</sup>. Additionally, linear correlations appear to exist between ν<sub>Mo=O</sub> and k<sub>1</sub> (k<sub>1</sub>=specific rate constant), σ<sub>p</sub>, and E<sub>pc</sub>. These data may enhance our understanding of the oxygen atom transfer mechanism of these complexes.

THE "RAPID LIFETIME DETERMINATION METHOD" FOR TREATING KINETIC DATA: AN ERROR ANALYSIS. R. Ballew, J. N. Demas, and B. A. DeGraff, Chemistry Departments, University of Virginia, Charlottesville, VA 22901 and James Madison University, Harrisonburg, VA 22807. The "rapid lifetime method" (RLD) of Ashworth allows the rapid evaluation of kinetic parameters for single and double exponential decays. For properly collected data, parameter evaluation is roughly 100-1000 times faster than the traditional linear least squares fitting method. While the RLD is less forgiving about selection of the fitting region, under optimum conditions the loss of precision in the parameters is only about 20%. We will describe the RLD and give simple methods for evaluating its performance. Error surfaces that allow selection of the optimum data collection and estimation of the expected uncertainties in parameter evaluation will be described.



**PYROLYSIS OF CRUDE SHALE OIL CONSTITUENTS: THE PYRIDINES.** Shadan Beheshti, George W. Mushrush, and Wayne M. Stalick, Chemistry Department, George Mason University, Fairfax, Va 22030

Crude shale oil contains approximately 2% nitrogen by weight. Assuming an average molecular weight of 280 for the compounds present in crude shale oil, nitrogen containing compounds thus constitute about 40% of the total crude. Based on combined capillary column GC/MS analysis of nitrogen compounds found in crude shale oil, alkyl pyridine compounds, a major component of crude shale oil, were selected for study. Free radical decomposition was observed when 2-nonyl,5-methyl pyridine was pyrolyzed at 450°C. It was pyrolyzed in stainless steel reactor tubes at temperature and pressure conditions similar to the petroleum process known as delayed coking. Free radical attack at the alpha and gamma positions in the side chain was found to be the major pathway to reaction products. The total product slate and a pyrolysis free radical mechanism will be presented.

**REGULATION OF QUEUINE INSERTION INTO TRANSFER RNA: EFFECTS OF TUMOR PROMOTERS.** Bonnie Brooks and Mark S. Elliott, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. The rate of incorporation of queuine into tRNA during early phases of tumor promotion were determined as a measure of the activity and availability of the queuine insertion enzyme, tRNA-guanine ribosyltransferase. Fibroblasts derived from human neonatal foreskins were cultured and exposed to phorbol-12,13-didecanoate (PDD), 4-alpha-PDD (an inactive isomer) and tetradecanoyl phorbol acetate (TPA). The rate of tritiated-dihydroqueuine (rQT<sub>3</sub>) incorporation into the acid precipitable fraction (that containing tRNA) from a fibroblast culture was determined for each continuous passage of individually treated or untreated cultures. The insertion rates of rQT<sub>3</sub> in cells treated with active tumor promoters were significantly decreased when compared to untreated controls. The reduced rate of incorporation was observed in spite of the fact that tumor promoter treated cells routinely contained queuine-hypomodified tRNA. This argues that phorbol esters may either directly inhibit or down regulate the expression of tRNA - guanine ribosyltransferase, resulting in undermodified tRNA. Furthermore, this may be an important early event tumor promotion since most neoplastic cells contain queuine-hypomodified tRNA. (Supported by NIH/NCI grant #CPA-1-R29-CA45213-01)

**THE SUBSTRATE SPECIFICITY OF A tRNA RIBOSE METHYLTRANSFERASE.** Guojun Bu and Thomas O. Sitz, Department of Biochemistry, Virginia Tech, Blacksburg, VA 24061. We have detected a 2'-O-methyltransferase from nuclei of Ehrlich ascites cells which has high substrate specificity for tRNA isolated from the liver of mice treated with ethionine. This methyl deficient tRNA was an excellent substrate but represents a heterogeneous population of many different tRNAs with different levels of methylation. This enzyme did not use tRNA isolated from yeast, *E. coli*, and non-ethionine treated mouse liver as a substrate, but did use tRNA from Ehrlich ascites cells at half the efficiency of tRNA isolated from ethionine treated mouse liver. Synthetic substrates such as poly A, poly G, poly I, and poly U were not substrates, but poly C was a poor substrate. A cloned yeast phenylalanine tRNA gene transcript (a tRNA with no modification) also was not a substrate. When the methylated tRNA was isolated from a reaction and hydrolyzed, an alkaline stable fragment about four nucleotides long was found. Kinetic data suggested that the enzyme was acting processively under our assay conditions.



MASS SPECTROMETRIC MEASUREMENT OF GAS PERMEATION RATES IN MEMBRANES. Karen S. Burns and John D. Van Norman, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529, & Billy T. Upchurch, Chemicon Corp., Virginia Beach, VA 23451, & George M. Wood\*, NASA Langley Research Center, Hampton, VA, 23655. The permeability of gases through membranes is a very important physical property. Membrane gas permeation rates have traditionally been measured using manometric methods which, while applicable to any gas, require large area specimens for measurement. In this paper a mass spectrometric method is presented which enables permeability measurements for very small area specimens with a large range of values. The method entails the determination of the slope resulting from the simultaneous recording of increasing permeant gas pressure at the inlet to the ion source and the ion current obtained from monitoring a single mass peak. Results will be presented for oxygen, nitrogen and carbon dioxide permeation rates through selected polymeric materials including contact lens materials.

AFFINITY LABEL STUDIES ON D-AMINO ACID OXIDASE. R. A. Coleman and S. A. Barrett, Dept. of Chem., Col. of William and Mary, Williamsburg, Va. 23185. D-amino acid oxidase (E. C. 4.3.1.1) (DAAO) is a deaminating oxidoreductase that catalyzes the transformation of D- $\alpha$ -amino acids into their corresponding  $\alpha$ -keto acids. Three nitrobenzyl bromide isomers were studied as affinity labeling reagents of DAAO. The meta compound produced irreversible, time-dependent, active site-directed inactivation. The para isomer inactivated DAAO in a time-dependent manner; the inhibition, however, was not active site-directed, and activity was recovered after dialysis. The ortho compound inhibited DAAO at unusually low concentrations. Results suggested that the inactivation was taking place on a very rapid time scale. Various epoxides, along with selected nitrobenzene and benzoic acid derivatives, were also studied. (Supported in part by the Llanos-Sherman Research Scholarship Fund of The College of William and Mary.)

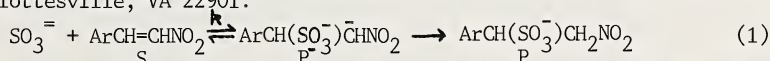
CHARACTERIZATION OF A CONDITIONED MEDIA FACTOR THAT POTENTIATES THE TUMOR PROMOTER EFFECT OF PHORBOL ESTERS ON QUEUINE TRANSPORT INHIBITION. Debra Crane and Mark S. Elliott, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23509. Phorbol ester tumor promoters induce queuine hypomodification of transfer RNA (tRNA). This effect is due in part to inhibition of queuine uptake into the cells and results in reduced substrate availability for the tRNA modifying enzyme. Queuine uptake inhibition is observed only in early passage human fibroblasts and not in late passage cells. Late passage fibroblasts often show stimulation of queuine uptake. Loss of queuine uptake inhibition through subculturing is related to loss of an endogenous conditioned media factor that enhances phorbol ester tumor promoter effects. Epidermal growth factor (EGF), fibroblast growth factor (FGF) and platelet derived growth factor (PDGF) have all stimulated queuine transport, both alone and in combination with phorbol esters. Interferons (alpha, beta and gamma) and poly I.C (an interferon inducer) all mimicked conditioned media factor with and without phorbol esters, shutting down queuine transport. Since tRNA from neoplastic cells is under modified with respect to queuosine, the identification of this factor may be significant in understanding endogenous control of neoplastic transformation. (Supported by NIH/NCI grant #CPA-1-R29-CA45213-01)

NONLINEAR LASER SPECTROSCOPY OF SURFACE ADSORBATES. Stephanie A. Cresswell and Jack K. Steehler, Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22901.

The study of surfaces has become increasingly important in gaining a full understanding of the events occurring at surfaces and interfaces. Analysis of surface adsorbates using multiresonant second order nonlinear spectroscopy allows for study of surface species with no interference from the bulk medium. This surface selectivity occurs because generation of a second order nonlinear signal is limited to environments lacking a center of inversion and is thus symmetry forbidden in the bulk medium. The use of multiresonant experiments allows for molecular specificity. By matching incident frequencies with the surface component's electronic resonances, the associated sum signal becomes enhanced. In the case of multiple adsorbates, individual components can be studied simply by tuning incident frequencies to the molecular resonances of the desired component. The potential range of applications includes such systems as electrode/solution interfaces, biological membranes, surfactants, lubricants, and corrosion inhibitors.

The basic principles allow for determination of surface coverages and molecular orientations. These factors were verified in a model system consisting of organic dye molecules adsorbed on fused silica disks. The ability to use multiple resonances for the selective study of individual adsorbates in multicomponent systems has also been demonstrated. Results for some of these studies will be discussed and interpreted with a proposed model for the system.

KINETICS OF THE NUCLEOPHILIC ADDITION OF CARBONATE, SULFITE AND THIOSULFATE IONS TO  $\beta$ -NITROSTYRENES. Thomas I. Crowell, Dept. of Chemistry, Univ. of Va., Charlottesville, VA 22901.



Sulfite ion adds to 3,4-methylenedioxy- $\beta$ -nitrostyrene (S) to form the sulfonate (P). The high rate constant,  $417 \text{ M}^{-1}\text{s}^{-1}$  ( $\text{H}_2\text{O}$ ,  $25^\circ$ ), shows sulfite to be a much stronger nucleophile than hydroxide ion ( $k \approx 0.69$ ) in contrast to their relative reactivities at saturated carbon atoms. Reaction 1 is acid-inhibited below pH 7 as  $\text{SO}_3^-$  is converted to unreactive  $\text{HSO}_3^-$ . Thiosulfate ion reacts more slowly ( $k = 5.1 \times 10^{-4}$ ) with complex kinetics.

The hydrolysis of S is catalyzed by carbonate ion, rate constant  $k = 2.7 \times 10^{-3} \text{ M}^{-1}\text{s}^{-1}$ . Since the deuterium solvent isotope effect  $k_{\text{H}_2\text{O}}/k_{\text{D}_2\text{O}}$  is near unity (Crowell, J. Org. Chem., 1983, 48, 3294), nucleophilic addition of  $\text{CO}_3^{2-}$  to S is postulated with subsequent hydrolysis of the unstable carbonate ester.

TRANSITION METAL COMPLEXES OF MONOQUATERNIZED DIAZINE CATIONS. Willie L. Darby and Yvonne A. Green\*, Dept. of Chem., Hampton Univ., Hampton, VA 23668. The heterocyclic cations formed by the monoquaternization of pyrazine, pyrimidine, and pyridazine do not exhibit basic properties toward the proton in aqueous solution, their  $K_{a2}$  values being estimated ca  $10^{-4}$ – $10^{-5}$ . These monoquaternized cations, however, coordinate with the halide of the divalent metal ions of  $3d^7$  to  $3d^{10}$  electronic configurations, Co(II) to Zn(II), forming a variety of, thermally stable crystalline complexes having the general formulas  $[\text{MX}_3(\text{L}^+)]$ ,  $[\text{MX}_4(\text{L}^+)_2]$ ,  $[(\text{L}^+)_2 \text{MX}_4^{2-}]$ . The formula and geometry of the complex formed generally depends on several factors, e.g., the metal ion, the halide, the ligand and the metal-to-ligand ratio. The structural, magnetic, and spectral properties of the complexes are discussed in terms of the influence of the positive charge on the heterocyclic N-donor atom and of the electronic and steric effects existing in these systems.

ALPHA ELIMINATION FROM TRANSITION METAL SILICON COMPLEXES.

Emma W. Goldman, and Colleen Kelley\* and Michael Gwaltney\*, Dept. of Chemistry, University of Richmond, Richmond, VA 23173. Hydride abstractions from organotransition metal complexes are well known. Similar abstractions from silicon in compounds with metal-silicon bonds have not been isolated. A series of compounds  $(\eta^5\text{-C}_5\text{H}_5)\text{Fe}(\text{CO})_2\text{Si}(\text{X})\text{R}_2$  (where X = H, -OMe; and R = methyl, phenyl, mesityl) have been prepared. Their reactions with trityl cation and trimethylsilyl triflate, as well as photochemical reactions, have been investigated. Reaction with trityl cation leads to hydride abstraction when X = H. The products and their reaction pathways will be discussed.



EFFECTS OF DIETARY ZINC & VITAMIN B<sub>6</sub> DEFICIENCY ON ESTROGEN DIRECTED PROTEIN SYNTHESIS IN THE MATURE RAT UTERUS. Bhadra Gunsekera & G.E. Bunce. Dept. of Biochemistry & Nutrition, Va Polytechnic Inst., Blacksburg, Va 24061.

The uterine Thymidine kinase (TK) activity has been assayed to determine if Zn deficient, non pregnant sexually mature rats would be hyporesponsive to an estrogen challenge. A vitamin B<sub>6</sub> deficient group was also tested for a hypersensitive response to estrogen. Sexually mature Sprague-Dawley rats were fed a semi purified diet containing either 40 or 1 ppm Zn or no added B<sub>6</sub> for three weeks, ovariectomized and two weeks later injected IP with 5µg of I<sup>7</sup> E<sub>2</sub>. A 4 fold increase in TK activity over the vehicle (95% saline, 5% EtOH) injected group was observed in ad libitum and restricted fed control groups between 42 & 48 h post E<sub>2</sub> injection. This peak activity declined to the control levels 60 h post E<sub>2</sub> injection. The B<sub>6</sub> deficient diet fed animals appeared to achieve a maximum response 6h prior to dietary controls. The Zn deficient diet fed animals appeared to reach 70% of the maximum control values 48h post E<sub>2</sub> injection. However these apparent differences failed to show significance at the 5% level of probability.

(Supported by USDA Grant No. 86-CRGR-I-1946.)

DETERMINATION OF TAMOXIFEN IN BIOLOGICAL FLUIDS. Janice Kiss, P. Pleban, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529; and A. Acosta, J. Swanson, S. Dehninger, Andrology Laboratory, The Jones Inst. for Reproductive Med., Med. Col. of Hampton Roads, Norfolk, VA 23507. Tamoxifen (Ta) is a triphenylethylene-derived compound classified as an antiestrogen which will stimulate ovulation and spermatogenesis. The most well-known use of Ta is as an antineoplastic agent in patients with estrogen receptor positive breast tumors. In our study, we have modified the HPLC method of Mikkelsen et al. (Fertil. Steril. 46: 322, 1986) for determination of Ta and its' metabolites N-desmethyl Ta and 4-OH Ta in serum and human semen. In addition, trans clomiphene citrate (tCC), another triphenylethylene compound, was used as an internal standard. Detection of the compounds was made using postcolumn irradiation followed by measurement of the fluorescent products. The UV induces the conversion of the stilbene structure into a rigid, highly fluorescent phenanthrene product. Ta was extracted from seminal plasma and serum using hexane followed by evaporation and reconstitution in 100% methanol. Mean extraction efficiencies were 99 and 92%, respectively, for 150 and 25 ng/mL Ta. The detection limit was 0.5 ng of Ta injected onto the column.

SUBSTITUENT EFFECTS ON THE KETO-ENOL TAUTOMERISM OF ACETALDEHYDE: A SEMI-EMPIRICAL STUDY. Brian W. Knight and Robert L. Ake, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. The keto-enol tautomerism of acetaldehyde was studied using the MNDO method. The energy difference between acetaldehyde and its corresponding tautomer was found to be 0.32 eV/molecule ( $\Delta(\Delta H_f) = 7.44$  Kcal/mol). Substitution of chlorine atoms for hydrogen atoms on the alpha carbon atom lowered this energy difference, but substitution on the carbonyl carbon raised this difference significantly. Finally, various mechanisms by which this tautomerism could take place were explored.

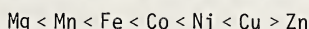


## DETERMINATION OF TYPE IV COLLAGENASE ACTIVITY IN HUMAN FOLLICULAR FLUID.

Teresa Lanier, P. Pleban, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529, and A. Acosta, S. Dehninger, J. Swanson, The Jones Inst. for Reproductive Med., Med. Col. of Hampton Roads, Norfolk, VA 23507. Type IV collagenase cleaves basement membrane collagen (type IV), and has been shown to be secreted by certain metastatic tumor cells. This enzyme has also been found in follicular fluid at the time of ovulation, and may be an indicator of fertilizability of the oocyte. We have adapted the method of Liotta *et al.* (Biochem. 20: 100, 1981) for measurement of the enzyme in follicular fluid aspirates from women undergoing *in vitro* fertilization procedures. The activity of the ammonium sulfate precipitated enzyme (0-60%) was measured using soluble 3-H Type IV collagen as a substrate. The Type IV collagenase was first activated by incubation with trypsin followed by addition of soybean trypsin inhibitor, *n*-ethylmaleimide, and aprotinin. The labeled substrate was then added and the reaction mixture incubated for 18 hours at 37 C. The reaction was stopped by addition of bovine serum albumin (carrier), 1% trichloroacetic acid, and 0.5% tannic acid. The undigested collagen precipitate was removed by centrifugation and the soluble 3-H fragments counted using a liquid scintillation counter.

A STABILITY RULER FOR METAL ION COMPLEXES. R. Bruce Martin, Chemistry Dept., Univ. of Virginia, Charlottesville, VA 22903.

For most ligands the order of binding strengths to the dispositive metal ions of the first transition row are given by the Irving-Williams stability series.

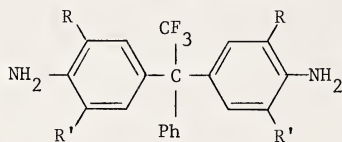


Though there is a systematic increase in stability constant for the first six metal ions, the position of  $\text{Zn}^{2+}$  is variable. By proposing a stability ruler for a given ligand that spans the first six metal ions, the binding of variable metal ions such as  $\text{Zn}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Pb}^{2+}$ , and  $\text{Hg}^{2+}$  may be described by placement on the ruler scale. Ruler length increases as nitrogen replaces oxygen donors. Introduction of a sulfur donor enhances binding of  $\text{Zn}^{2+}$ ,  $\text{Cd}^{2+}$ , and  $\text{Pb}^{2+}$ . For table of the stability ruler see J. Chem. Educ. 64, 402 (May 1987).

## INDOLE DERIVATIVES II. PRELIMINARY STUDIES ON THE SYNTHESIS OF MESOIONIC

THIAZOLO-as-TRIAZINOINDOLES. Godwin O. Mbagwu, Shelly Weeks and Natalie Carroll, Dept. of Chem., Va. State University, Petersburg, Va. 23803. The naturally occurring tetracyclic indole alkaloid, ellipticine, first isolated by Goodwin and co-workers in 1959 has elicited considerable biochemical and synthetic interest because of its potential as DNA reactive anti-tumor agent. Biophysical studies of several ellipticine derivatives by various workers have established that the tetracyclic ring system which resembles a purine-pyrimidine complementary base pair provides a favorable condition for intercalation in double stranded nucleic acids. In the course of preparing some novel "ellipticine-type" mesoionic compounds for SAR studies, we synthesized some analogs containing the thiazole nucleus. It is well known that many biologically active compounds contain thiazole or fused thiazole moiety. Modified ellipticine analogs may provide a new probe for further studies of structural requirements necessary for DNA reactivity and antitumor activity. (Supported by NIH Grant RR-08090-16)

NEW DIAMINE MONOMERS FOR CONDENSATION POLYIMIDES. Karen A. McGrady\* and Roy F. Gratz, Dept. of Chemistry & Geology, Mary Washington College, Fredericksburg, VA 22401. Two new diamine monomers, 1 and 2, were prepared by heating *o*-toluidine or 2,6-dimethylaniline with  $\alpha,\alpha,\alpha$ -trifluoroacetophenone in the presence of the corresponding hydrochloride salt. The structures were confirmed by NMR and IR spectroscopy and by elemental analysis.



1 R = CH<sub>3</sub>, R' = H

2 R = R' = CH<sub>3</sub>

The two monomers were reacted with pyromellitic dianhydride (PMDA) and 3,3',4,4'-benzophenonetetracarboxylic acid dianhydride (BTDA) in dimethylacetamide to give solutions of the polyamic acids. The polyamic acid solutions will be converted into polyimide films for further study.

ISOLATION OF LIPIDS FROM THE PLATE JELLYFISH. II. Susan K. Ohorodnik, C. E. Bell, Jr., K. G. Brown, Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508, S.G. Davis, and D. B. Spangenberg, Medical College of Hampton Roads, Norfolk, VA 23507. Lipid Extracts from Aurelia aurita, plate jellyfish, were subjected to analyses by 2-dimensional TLC and FT-IR spectrometry. Preliminary results indicate the presence of free cholesterol and cholesteryl esters, including cholesteryl acetate. The sessile polyp and ephyra stages were investigated as well as polyps in the process of strobilation. Comparison of 2D-TLC patterns are discussed.

#### LANTHANIDE COMPLEXES OF A SIX-NITROGEN ANALOG OF 18-CROWN-6.

A. Polo, J.R. Quagliano, L.M. Vallarino, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284.

The Schiff-base condensation of 1,2-diaminobenzene and 2,6-diformylpyridine was carried out in the presence of lanthanide nitrates as templates (mole ratio, 2:2:1). Two series of "true" macrocyclic complexes were obtained: (1) With the larger lanthanide(III) ions, the complexes had formula  $[ML(NO_3)_3] m(H_2O)$ , where M = La-Gd and L = C<sub>26</sub>H<sub>18</sub>N<sub>6</sub>; (2) With the smaller lanthanides, the complexes had formula  $ML(NO_3)_{3-n}(OH)_n m(H_2O)$ , where M = Eu-Lu and L was again C<sub>26</sub>H<sub>18</sub>N<sub>6</sub>. In both series, the ligand was shown to have a highly symmetrical 18-member cyclic structure with a six-nitrogen-donor cavity. In addition, a third series of complexes was obtained, having formula  $M(C_{26}H_{18}N_6 \cdot H_2O)_2(NO_3)_3 mH_2O$ , where M = La-Lu; these complexes were assigned a sandwich structure.

THE TRENDS OF MODERN CHEMISTRY IN WINEMAKING. Jacques Recht, Winemaster, Ingleside Vineyards, Oak Grove, VA 22443. This paper will lend itself to a discussion of very recent developments in winemaking. The role of octanoic and decanoic acids as stock fermentation elements and natural preservatives will be examined as well as the action of beta glucanase in wine production. The recently introduced laccase test for Botrytis cinerea will be discussed together with the discovery and action of ethyl oleanoate as a control for Botrytis. The paper will also include a discussion of the new cryo-extraction methods used in winemaking.

A VIRGINIA VINEYARD TODAY. Lee Reeder\*, Winemaker, Burnley Vineyard, Barboursville, VA 22923. This paper will attempt to present an accurate picture of a typical Virginia Vineyard as seen through the eyes of the winemaker himself. It will include a pictorial presentation of the activities, the challenges and rewards of winemaking.

OPTIMIZATION OF THE TUNGSTIC ACID TECHNIQUE FOR THE MEASUREMENT OF ATMOSPHERIC AMMONIA. Patricia D. Roberts, K. G. Brown, Dept. of Chemical Sciences, Old Dominion Univ., Norfolk, Va. 23529, P. J. Lebel and S. A. Vay, NASA/Langley Research Ctr., Hampton, Va 23665. Atmospheric Ammonia is the major gaseous alkaline constituent in the troposphere, it is a critical parameter in the rates of formation, transport, transformation and removal of sulfur and nitrogen aerosols. A major sink for odd nitrogen species is the photochemical conversion of  $\text{NO}_x$  to  $\text{HNO}_3$  with subsequent reaction with  $\text{NH}_3$  to form  $\text{NH}_4\text{NO}_3$ . This chemical reaction illustrates the need for a measurement technique which is specific for both  $\text{HNO}_3$  and  $\text{NH}_4$  collection. This technique utilizes the chemisorption of  $\text{NH}_3$  and  $\text{HNO}_3$  on a tube coated with tungsten oxide, followed by thermal desorption, separation, and detection in a chemiluminescent  $\text{NO}_x$  analyzer. Optimization of this technique for ammonia measurement and the development of a field and flight instrumentation has led to the first known reported simultaneous  $\text{HNO}_3$  and  $\text{NH}_3$  measurements in a biomass burn smoke plume.

THE RELEVANCE OF pH IN WINEMAKING. Skep Rouse\*, Winemaker, Montdomaine Cellars, Charlottesville, VA 22901. pH is undoubtedly one of the most important factors to be considered by the winemaker. It plays a vital role in the ripening of the grapes and mediates the susceptibility of the must and wine to spoilage. It also determines the effectiveness of  $\text{SO}_2$  with regard to the inhibition of both spoilage organisms and oxidation. pH plays an important role in the color of young red, red and blush wines and is a significant factor in the solubility of proteins in wine as well as the precipitation of potassium bitartrate, both of which are important in the stabilization of commercial red wines. The pH of a wine also plays a great role in the ability of the wine to age gracefully.

HYPOXANTHINE INDUCED DIFFERENTIATION OF CULTURED HUMAN LEUKEMIA CELLS. Gayle Singleton and Mark S. Elliott, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. Cultured leukemia cells appear to have a decreased amount of inosine in their tRNA. When cells with inosine deficient tRNA are placed in a hypoxanthine fortified media they incorporate hypoxanthine into their tRNA by the action of the enzyme tRNA hypoxanthine ribosyltransferase. This generates the nucleoside inosine in the tRNA. The cultured leukemia cell lines, HL-60

and CCRF-CEM's both incorporate hypoxanthine into their tRNA, as determined by tRNA hydrolysis and HPLC. We observed a difference in the levels of inosine in the control leukemia cells and the leukemia cells grown in the hypoxanthine fortified media. Immunofluorescent analysis of surface differentiation antigens for CCRF-CEM cells established differences that indicated a progression towards a more differentiated phenotype. Hypoxanthine treatment also dramatically inhibited cell growth in conjunction with partial induction of differentiation in both CCRF-CEM and HL-60 cultures. (Supported by NIH/NCI grant #CPA-1-R29-CA-45213-01)

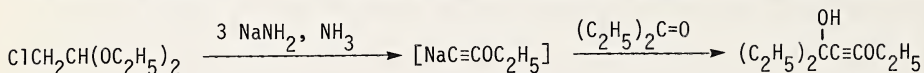


First- and Higher-Order Derivative Polarography/Voltammetry for an Electron Transfer Reaction Coupled with a Prior Chemical Reaction. Veriti Smith and Myung-Hoon Kim, Alfried Chemical Laboratories, Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23529

In the past, the derivative polarographic/voltammetric methods (DP/DV) have been discussed only for simple electron transfer processes. This study develops the theory of derivative polarography for a kinetic system where diffusion is coupled with a slow kinetics, i.e., for a reversible electron transfer which is coupled with a prior chemical equilibrium (CE-type mechanism). With computer-aided plots, properties of derivative expressions (first-, second-, and third-order) are analyzed in terms of various parameters such as (a) positions and separations of peak-potentials, (b) magnitude and ratios of peak-heights, and (c) magnitude and ratios of half-peak-widths. It is demonstrated that (1) the symmetry in the derivative curves which is characteristic of the simple reversible electron transfer reaction disappears as the kinetics of the system comes into play, (2) peaks which appear on the anodic side of the potential range in the second- and third-derivatives are more influenced by the prior kinetics than those appear on the cathodic side, thus generating asymmetry in the curves, (3) analysis of the degree of the asymmetry as measured with some of the parameters can yield values of the equilibrium constant, and rate constants for the chemical step occurring prior to the electron transfer from the electrode. Suitability of various parameters as diagnostic tools for investigating the CE-type mechanism is also discussed based on their sensitivity to the prior kinetics.

RECENT STUDIES IN ALKOXYALKYNE SYNTHESIS. Wayne M. Stalick, Department of Chemistry, George Mason University, Fairfax, Virginia 22030

The most common methods for producing 1-alkoxyalkyne derivatives are multi-step, relatively low yielding pathways. This paper describes a high yielding, one-pot reaction using readily available chloroacetaldehyde dialkyl acetals as starting materials. The reaction is initiated by sodium amide and the intermediate acetylide anion thus produced, reacts readily with a variety of electrophiles such as alkyl halides, carbonyl compounds or water to produce the desired products. The following general equation summarizes the reaction:



NEW PROTEIN LABELS FOR TIME-RESOLVED FLUORESCENCE IMMUNOASSAY.

R. Thompson, Naval Research Laboratory, Washington, D.C. 20375, and L.M. Vallarino, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284.

It has been shown that time-resolved methods can offer significant improvement in the sensitivity of fluorescence immunoassays. However, the labels commonly used for this purpose (chelate complexes of europium(III) and terbium(III)), present some disadvantages; in particular, they require excitation with low-wavelength UV radiation and often the addition of a separate enhancer solution. We have developed a bifunctional chelating ligand, 5-isothicyanato-1,10phenanthroline, that allows the facile conjugation of a fluorescent ruthenium(III) complex to any desired substrate containing primary amino or hydroxyl groups. This new fluorescent label is excited in a visible region for which laser sources are easily available, has no need for a separate enhancer, and provides good time-resolution.

ION CHROMATOGRAPHY OF TRACE METALS. I.T. Urasa, and Sang Ho Nam, Department of Chemistry, Hampton University, Hampton, VA 23668. One of the attractive features of Ion Chromatography (IC) is its capability for speciation measurements. This capability is especially enhanced if IC is equipped with an element selective detector (ESD). This paper discusses the use of d.c. plasma atomic emission spectrometry (DCPAES) as an element selective detection method for ion chromatography and the application of the combined analytical system to speciation work. By monitoring the atomic emission of selected trace metals, the chromatographic effluents containing species of these metals were detected via d.c. plasma excitation. The variation of chromatographic parameters such as column packing, eluent concentration, and preconcentration procedures provided additional dimensions for improvement on measurement sensitivity and selectivity. The results obtained indicate that by careful selection of experimental parameters, various species of chromium, manganese, and vanadium can be separated and detected in the ppb concentration range. The procedure was applied in the speciation of these metals in process streams, and other selected materials.

CHROMATOGRAPHIC CHARACTERIZATION OF PLATINUM-CONTAINING COMPOUNDS. I.T. Urasa and Valerie D. Lewis, Department of Chemistry, Hampton University, Hampton, VA 23668. In recent years, several platinum containing compounds have been developed and tested for antitumour activity. The characterization of such materials has relied heavily on state-of-the-art analytical methods not only to establish their purity, but also to monitor their metabolic and other degradation products in various media. It is imperative therefore that the analytical protocol employed for such measurements has the capability to separate and quantify the various fractions that may be present in what may be very complex matrix. This paper will discuss the use of High Performance Liquid Chromatography (HPLC) and Ion Chromatography (IC) coupled with spectroscopic techniques to study selected platinum compounds, some of which have been reported as being antitumour agents.

PRECONDITIONING OF CO OXIDATION CATALYSTS. John D. Van Norman, Kenneth G. Brown, & Jacqueline Schryer\*, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529 and David R. Schryer\*, NASA Langley Research Center, Hampton, VA 23655. Platinum on a tin (IV) oxide substrate has been shown to be an excellent catalyst for the oxidation of CO. The recombination of oxygen and carbon monoxide formed from the decomposition of carbon dioxide in a closed-cycle carbon dioxide laser is an example of the use of this catalyst. The efficiency of the catalyst as a function of time is dramatically dependent upon the conditions of preconditioning of the catalyst prior to its use. The catalyst used in this investigation is 2% platinum on tin (IV) oxide. The effects of pretreatment gas composition, temperature, duration and flow rate will be presented and the role of water vapor in both the pretreatment gas and the reaction gas mixture will be discussed.

EVALUATION OF A HELIUM DISCHARGE DETECTOR FOR GAS CHROMATOGRAPHY. Margaret Ware\*, Mark Argentine\*, and Gary Rice\*, Dept. of Chem., Col. of William and Mary, Williamsburg, VA 23185. A helium discharge detector (HDD) has been reported as an element selective, multielement detector for gas chromatography (GC) (1). An unusual feature of the HDD is that the visual intensity of the discharge is on the order of an ordinary candle, yet a number of elements, including the halogens, S, P, C, and Hg can be detected at low picogram levels from characteristic atomic emission generated in the discharge. A persistent problem has been the adverse effects of oxygen contamination, which gives rise to molecular CO emission in the UV region from carbon containing analytes, to the extent that signals can be observed at nanogram levels or less at virtually any UV wavelength. The practicality of utilizing emission lines in the near IR to circumvent this problem for several elements will be discussed. We are also currently investigating what He states are the primary sources of analyte excitation, as well as the excitation temperatures associated with the HDD. (Supported by the Jeffress Memorial Trust, Grant #J-115)  
(1) Rice, G. W.; D'Silva, A. P.; Fassel, V. A. Spectrochim. Acta 1985, 40B, 1573-84.

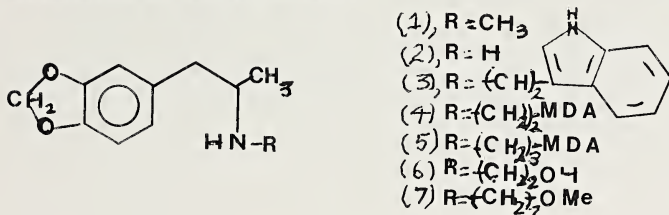
BICYCLIC TOSYLHYDRAZONE REACTIONS. George S. Whitney, Department of Chemistry, Washington & Lee University, Lexington, VA 24450. When a ketone reacts with toluenesulfonyl hydrazine to form the hydrazone, and this is treated with a base, Bamford & Stevens found that toluenesulfinate is eliminated, and then nitrogen. Under aprotic conditions, carbenes are often formed, and these intermediates can insert or make alkenes. We wondered what might happen if we treated the diketone of the cage formed by radiating the Diels-Alder adduct of cyclopentadiene with quinone, which can do neither without rearrangement. Evidence points to formation of benzocycloheptatriene. And two of the benzene's carbons must come from cyclopentadiene, the other four from quinone.

CARBENES AND DIMSYL SODIUM. George S. Whitney, Brian Haggerty and Craig Keanna, Department of Chemistry, Washington & Lee University, Lexington, VA 24450. In the Bamford-Stevens reaction, the compound camphor has often been used as a model compound. It easily reacts with toluenesulfonyl hydrazine to give a hydrazone, which in turn may be treated with base to give three possible products. With protic solvents, the base reaction tends to give mostly camphene by rearrangement; with aprotic, mostly tricyclene by carbene insertion. Shapiro found that methyl lithium gave only bornene. We have studied the reaction with the sodium derivative of dimethyl sulfoxide, in that solvent, and found mostly tricyclene. (Supported by Robert E. Lee Undergraduate Research Grants-in-Aid.)

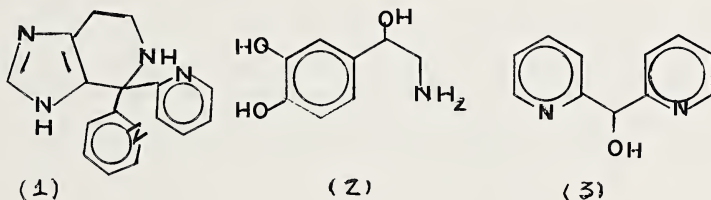
THE SCIENCE OF WINEMAKING AND AN OVERVIEW OF VIRGINIA WINERIES. Roy L. Williams, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. This paper will introduce the audience to some of the more "common" or classical methods of winemaker. The general producers for the preparation of red and white wines will be discussed together with developing chemistry of the wine. This discussion will be followed by a description or overview of the recent developments in the organization and distribution of Virginia Wineries and the types of wines which are being produced within the state of Virginia.



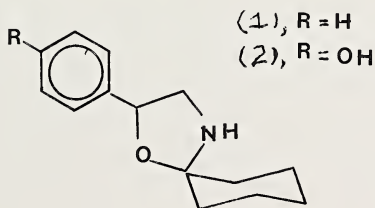
SYNTHESIS AND EVALUATION OF NOVEL ANALOGS OF METHYLENEDIOXYMETHAMPHETAMINE (MDMA). Roy L. Williams and Deborah Johnson, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. We have recently begun a study into the synthesis and evaluation of certain analogs of the recreational drugs known as MDMA (1) or MDA (2). This study has led to the successful synthesis of a tryptamine analog (3) as well as two "extended" analogs (4) and (5). Perhaps the most interesting compounds, in terms of biological activity, were the hydroxy (6) and methoxy (7) analogs. These latter two compounds exhibited exceptional CNS stimulation in laboratory mice.



THE SYNTHESIS AND EVALUATION OF POTENTIAL CARDIOVASCULAR DRUGS: 2,2<sup>1</sup>-DIPYRIDYL-METHANOL ANALOGS. Roy L. Williams and Karen Parker, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. We have recently shown that compound (1) can effectively lower blood pressure in rats and may be acting as a norepinephrine NE (2) antagonist. We have now synthesized a simpler target compound, the 2,2-dipyridymethanol (3) which we anticipate to also exhibit NE antagonist activity. The synthesis, spectral properties and preliminary biological evaluation of (3) will be discussed together with other possible target compounds based on this study.



SUBSTITUTED OXAZOLIDINES AS POTENTIAL NOREPINEPHRINE ANALOGS. Roy L. Williams and Tammy Wang, Dept. of Chemical Sci., Old Dominion Univ., Norfolk, VA 23529. As part of our continuing search for new cardiovascular drugs, we have recently synthesized several interesting oxazolidines (1) and (2), by direct condensation of suitable phenethyl amines with cyclohexanone. Compound (2) has now been shown to cause a significant increase in both the blood pressure and heart rate of laboratory rats (1p). This type of activity has led to classify (2) as a potential  $\beta$  agonist. The synthesis and evaluation of these new compounds will be discussed.



COMPARISON OF INOSINE LEVELS OF TRANSFER RNA IN NORMAL AND CLINICALLY DERIVED LEUKEMIA BLOOD CELLS. Christine Witte and Mark S. Elliott, Dept. of Chem. Sci., Old Dominion Univ., Norfolk, VA 23529. Inosine is a modified nucleoside found in the first position of the anticodon of up to eight transfer RNA and it arises as a post-transcriptional enzymatically catalyzed exchange of hypoxanthine for adenine in the tRNA primary transcript. Previously, a patient in the blast phase of chronic myelogenous leukemia was shown not to have any inosine in his tRNA. We now show inosine levels of tRNA are also depressed in a number of different types of clinically derived leukemias; chronic lymphocytic, acute lymphocytic, and acute myelogenous, as well as chronic myelogenous leukemia. If inosine is present in the anticodon it has the ability to read at least three, and possibly four, different codons for the same amino acid. This expanded codon recognition potential of a specific tRNA molecule may be important to the rate of production for crucial proteins involved with the normal function of the lymphocyte of myelocyte. Furthermore, loss of inosine from tRNA may be an important event in development of neoplastic disease. (Supported by NIH/NCI grant #CPA-1-R29-CA45213-01)

## Education

USING CONCEPT MAPS AND WORD FAMILIES AS A FRAMEWORK FOR LEARNING. Ed Brandt, Ph.D. Shenandoah Col., Winchester, VA 22601. The technique of concept mapping (D.P. Ausubel) emphasizes crucial interrelationships. Maps can serve to organize and sequence instruction. The role and development of maps will be discussed and examples provided. Word families are usually sequential and may be viewed as a linear map. Each word series has a logical pattern or order and in my application may convey an anatomical or physiological meaning. Use of word families will allow students to simplify or summarize complex processes. Often a series of related words can be used to extend or refine a portion of a concept map. Concept maps and word families are designed to supplement classroom learning. They are useful as a study guide tool especially when student generated. Events that are not readily mapable can frequently be placed into logical word families. Teaching students to map and create word families establishes a framework for meaningful learning.

VIRGINIA MUSEUM OF NATURAL HISTORY EDUCATIONAL PROGRAMS. Elizabeth W. Lester, Education Department, Virginia Museum of Natural History, Martinsville, Virginia. 24112. As the newly designated state museum of natural history, the Virginia Museum of Natural History offers educational programs on a statewide basis. Utilizing museum collections and resources, the Education Department is now offering nine outreach programs which are adaptable for students in elementary through secondary schools. Program titles currently available are "Virginia Indians", "Insects", "Fossils", "Dinosaurs", "Africa", "Birds", "Plants of Virginia", "Rocks and Minerals", and "Reptiles and Amphibians". Programs to be included in the 1988-1989 schedule are "Mammals", "Archaeology", "The Solar System", "Weather and Climate", and "Human Origins". The museum also offers teacher workshops, traveling exhibits, lectures and programs statewide. The VMNH Educational Publications series will begin this year with a volume on Virginia's fossils and geologic history. At the graduate level the museum and University of Virginia will cooperate in a new interdisciplinary Ph. D. program in Evolutionary Biology, to begin Fall 1988. With future branch museums planned for Blacksburg, Charlottesville, and Richmond, the Virginia Museum of Natural History is in an excellent position to serve as a resource base to educators across the Commonwealth.

STUDENT EDUCATIONAL OUTCOMES ASSESSMENT -- A FACULTY-CENTERED, LOW TECH, LOW BUDGET APPROACH. Bernard H. Levin, Professor/Psychology & James C. Sears,\* President, Blue Ridge Community College, P. O. Box 80, Weyers Cave, Virginia 24486. Student educational outcomes assessment systems are now required of all public Virginia colleges. This paper describes a system designed, operated, and managed by faculty. This system produces curricular improvement with minimal organizational strain. Both individual program assessment plans and curricular decisions made by faculty members are subject to college-wide peer review.

AN INTERDISCIPLINARY APPROACH TO INTRODUCING HIGH SCHOOL JUNIORS AND SENIORS TO ELECTRON MICROSCOPY. Cheryl A. Lindeman, Central Va. Magnet Sch. for Science and Technology, Lynchburg, Va. 24502. A twenty-hour short course in electron microscopy is designed for gifted high school students to learn the protocol for preparation and interpretation of micrographs using an HITACHI HS-7S transmission electron microscope. The overall objectives of the course are to provide students hands-on experience using sophisticated technology, to involve students in problem solving, and to involve students in a research project which relies on physics, chemistry, math, and biology concepts when interpreting micrographs. The course is divided into five units which include background reading in scientific journals, operation and theory of the TEM scope, preparation of thin film grids for bacteria specimens, photography, and project paper. Under instructor's supervision the students operate the TEM scope and develop an awareness of the interdisciplinary applications of TEM in science.

MORE THAN ONE WAY TO LIGHT LIGHTS: INDUSTRY SPONSORED ELECTRICAL ACTIVITIES FOR ELEMENTARY TEACHERS. Richard J. Rezba, VCU, Jo Kennedy\*, Lynn Wilson\*, Virginia Power.

Energy is Fundamental is a teacher training program and educational package designed to strengthen science instruction in elementary schools. Planned and implemented through a collaborative effort of Virginia Power, the Virginia Department of Education, Virginia Commonwealth University's School of Education, and school systems in the Virginia Power's service area. In the first phase of the program, teachers attend an ELF workshop where they learn to use participatory activities to teach fundamental electricity and energy concepts. Each school receives a comprehensive kit of equipment and supplies for implementing the activities. In the second phase, these teachers conduct follow-up workshops in their home schools/districts. During the pilot year four ELF workshops were conducted for 87 elementary teachers from 28 Virginia and North Carolina School Districts. These teachers conducted 54 follow-up sessions to train 971 fellow teachers in the use of the kit. Survey results indicated an average of 140 students in 120 schools have participated in hands-on learning of energy and electricity for a total of 17,000 students.

PHYSICS ACTIVITY: IS LASER LIGHT A WAVE? D. A. Whitney, Dept. of Physics and D. Q. Robinson, Dept. of Middle and Secondary Education, Hampton Univ., Hampton, VA 23668. A laboratory investigation of the behavior of laser light was conducted in which wave properties of a He-Ne laser were measured. This was performed by a small group of college students and then by two groups of high school students. The first part of the experiment was to demonstrate the laser beam's straight line propagation through reflection and refraction and to raise the question, "How can laser light be a wave?" The next portions of the investigation were to measure the speed of light, to observe the relationship of color with wavelength of various spectral lines, and to find the wavelength of laser light. The investigation utilized the ripple tank to observe planewave propagation, diffraction and interference of water waves and, then, diffraction and polarization of laser light. A brief discussion of this activity will be presented with a comparison of the performance of the two student groups. (Supported by NSF Model Middle School Science Improvement Program and General Telephone and Electronics)



## Engineering

PRODUCTION OF HIGH  $T_c$  SUPERCONDUCTORS, Robert Andes Jr.\*, John Mathieson\*, Robert Ake, Dept. Chem., ODU, Norfolk, VA 23529 & Linda Vahala, Dept. ECE., ODU, Norfolk, VA 23529. We study possible improvements in the technique of production of the typical  $YBaCuO$  high  $T_c$  superconductors. We design and implement apparatus to qualitatively test these new techniques and develop procedures allowing production of superconductor material on a larger scale. An analytic fit is made to the experimental data obtained. The "Meissner" force is measured at a fixed height. There is vortex penetration of the magnetic field into the superconductor (i.e. type II). Our data is represented as a function of pellet thickness and our theory is compared to present theories available.

"AN INVESTIGATION INTO A RELIABLE METHOD OF DETERMINING THE QUALITY FACTOR OF HIGH  $T_c$  SUPERCONDUCTING CAVITIES," Louis Balagtas\*, Daniel Wood\*, Chandrashekar Masti\*, Amin Dharamsi, and Linda Vahala, Department of Electrical and Computer Engineering, Old Dominion University, Norfolk, Virginia, 23529-0246. Because of very high Q's of the superconducting cavities, the decrement method is most appropriate. The precision of the Q determination is a function of various factors--stability, accuracy in the measurement of frequencies, time delay, and output energy. Techniques for providing error reduction in the measured Q are discussed and comparison made with methods used in non-superconducting cavities.

ELECTROPLATING THIN FILMS OF Y-Ba-Cu-O ONTO A SILVER SUBSTRATE Guy L. Bilodeau\*, Erick C. Rozelle\*, Robert J. Spagnuolo Jr.\*, Linda Vahala, and Amin Dharamsi, Dept. ECE., ODU, Norfolk, VA 23529. We will report the results of thin film deposition of a polycrystalline  $YBa_2Cu_3O_{7-x}$  superconductor on a silver substrate using electroplating techniques used by Piel and Ponto in Wuppertal. The deposition rate and the critical current density of the resulting deposition of high  $T_c$  superconductor onto the silver substrate will be measured. We will also report on the temperature dependence of the electrophoresis process.

SEMI-QUANTITATIVE ANALYSIS OF HIGH  $T_c$  SUPERCONDUCTORS. Carol Farrant\*, Seong Chen\*, Robert Ake, Dept. Chem., ODU, Norfolk, VA 23529, Amin Dharamsi, Dept. ECE., ODU, Norfolk, VA 23529. Fourier Transform Infrared (FTIR) was used to study high  $T_c$  superconductors. The spectroscopic study was undertaken in part to determine whether the method could assess sample quality. The samples were prepared in KBr pellets and studied in the spectral region  $400\text{ cm}^{-1} - 800\text{ cm}^{-1}$ . A characteristic band for  $YBa_2Cu_3O_{7-x}$  occurs at band  $573\text{ cm}^{-1}$ . The nonsuperconductor  $Y_2BaCuO_5$  exhibits bands at 610, 556, 510,  $453\text{ cm}^{-1}$ . The new  $Bi_2Sr_2CaCu_2O_{8-x}$ ,  $0 < x < 1$ , which has a  $T_c \sim 120K$ , has only one band in this region at  $602\text{ cm}^{-1}$ . The use of FTIR as a monitor of sample quality will be discussed.

## Environmental Science

NUMBERS AND DISTRIBUTION OF AN URBAN RACCOON POPULATION AND THE IMPACT OF A RABIES EPIZOOTIC IN THE MID-ATLANTIC STATES. Jill Anthony, Dept. of Environmental Sciences, Univ. of Va., Charlottesville, Va. 22904, J. Childs, G. Korch, G. Gurri-Glass, Dept. of Immunology and Infectious Diseases, Johns Hopkins Univ., Baltimore, Md. 21205, and L. Ross, Bureau of Animal Control, Baltimore City Dept. of Health, Baltimore, Md. 21230. The effects of a rabies epizootic and increased control efforts on an urban raccoon population were assessed in Baltimore, Maryland from January 1984 to June 1987. Records of 1352 raccoons either trapped alive in residential areas or removed dead from city streets by Municipal Animal Shelter wardens were examined for temporal patterns in removal rates and land use association. The number of raccoons trapped alive varied seasonally, while annual totals remained stable over three years before showing a marked decline in 1987. The number of raccoons removed dead remained constant over the first three years and showed a decline in the last six months of the study. Raccoons were associated with waterways and single-unit residential areas more frequently than with densely-populated areas. Both the rabies epizootic and increased city and private control appear to have contributed to the decline in the number of Baltimore city raccoons.

MEASUREMENT OF RADIOACTIVITY IN ALBEMARLE COUNTY SOIL SAMPLES. S. R. Bose, R. U. Mulder, and T. G. Williamson, Dept. of Nuclear Eng. and Eng. Phys., Univ. of Va., Charlottesville, VA 22903. The activities of long lived alpha, beta and gamma emitting radionuclides, from bomb fall-out and natural sources were determined in central Virginia soil samples. Samples were collected from 17 sampling points throughout Albemarle County representing 8 different types of soils. Samples were analyzed for measurement of gross alpha, gross beta, Cs, K, and Th activities. The gross alpha activity ranged from 147 to 1233 Bq kg<sup>-1</sup> with an average of 410 Bq kg<sup>-1</sup> soil, whereas the gross beta activity varied between 185 and 634 Bq kg<sup>-1</sup> with an average of 333 Bq kg<sup>-1</sup> soil. Uranium and Thorium were obtained by both direct gamma counting and neutron activation analysis. For undisturbed soils, secular equilibrium between <sup>238</sup>U and <sup>226</sup>Ra was found to exist but this was not true for <sup>232</sup>Th and <sup>212</sup>Pb. For disturbed soils, secular equilibrium of <sup>238</sup>U and <sup>232</sup>Th with their respective daughters were not found to maintain in the decay chain.

PROTECTING ACID-SENSITIVE LAKES: THE FLAT TOP EXPERIENCE. David A. Coahran, Donald J. Orth, and Louis A. Helfrich, Dept. of Fisheries & Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Flat Top Lake, Raleigh County, W.Va., received an application of 28.8 dry metric tonnes of limestone to its east arm (62.9 acres) to increase the capacity to buffer acidic inputs. The west arm (113.4 acres) did not receive a direct treatment and was used as a reference to assess water quality and biological responses. Alkalinity (mg/l as CaCO<sub>3</sub>) increased 43% in the east arm 1 week after liming. Phytoplankton biomass (chlorophyll a) increased steadily following the treatment, however no significant differences between the limed and unlimed arms were detected. Zooplankton biomass was higher in the unlimed arm prior to the treatment and was similar in both arms after the treatment. Phytoplankton primary productivity (O<sub>2</sub>-evolution method) was not significantly different between the arms prior to and immediately after the treatment. Productivity was significantly higher (P=0.037) in the limed arm three weeks after the treatment. Comparisons of limed versus unlimed arms were confounded in later samples because of a steady diffusion of dissolved limestone into the unlimed arm which contaminated the reference. Alkalinity was similar (25 mg/l) in both arms six weeks after the lime application.

**BIOACCUMULATION OF HERBICIDES: ECOLOGICAL IMPLICATIONS FOR FRESHWATER MUSSELS.** Sally D. Dennis, Dept. of Biol., Radford U., Radford, VA 24142 and John M. Bates\*, Ecological Consultants Inc. Shawsville, VA, 24162. Investigation of freshwater mussel "kills" in the lower Tennessee River (Kentucky Lake) revealed mortalities as high as 80% in two discontinuous river reaches. Sediments from these areas showed toxic effects when screened using Daphnia magna (48 hr. chronic test). Chemical analyses of these sediments showed trace amounts of a number of organic compounds including several used as herbiciding agents. Since it is well documented that large quantities of herbicides have been applied to the lake for many years, for the purpose of weed control, further analyses for such compounds were made. Periphyton samples taken from selected areas revealed trace quantities of several pesticides/herbicides. Analyses of freshwater mussel tissues indicated presence (<0.10 ppm) of most of the same compounds; simazine, however, was found in concentrations of <2 to >11 ppm indicating possible bioaccumulation. This particular triazine has apparently been widely used within the Tennessee River watershed as a defoliant and/or general herbicide. Data tend to indicate a correlation between concentrations of simazine and high mussel mortalities; sediment and periphyton data tend to corroborate this hypothesis. Determination of lethal body burdens and specific sources of contamination are being investigated.

**DEVELOPMENT OF CRITERIA FOR THE PREDICTION OF INDOOR RADON.** Douglas Mose and George Mushrush, Center of Applied Science, George Mason University, Fairfax, VA 22030

A study of indoor radon in about 1000 homes in Fairfax County, VA, has resulted in two methods for the prediction of indoor radon concentrations:

- (1) Predictions for communities, in terms of the percent of homes above the EPA "Action Level" of 4 pCi/l is accomplished using aeroradioactivity maps and geological maps.
- (2) Predictions for individual homesites, in terms of "Less Than 5 pCi/l, From 5 to 15 pCi/l, and Above 15 pCi/l" is accomplished by using local soil radon and percolation test data.

An in-progress study of radon reduction by the installation of sub-slab ventilation appears to work quite well in areas of different aeroradioactivity, geology and soil permeability. It is clear that while some communities in Virginia have much more than 50% of the homes above the 4 pCi/l, and that the geological material that underlies most of the problem homes in Fairfax County extends throughout Virginia and adjacent states, the reduction of radon concentration in most homes is easily accomplished by simple fan-driven removal of soil gas from below the basement or base-level slab.

**ANALYSIS OF IMPEDIMENTS TO SPAWNING MIGRATIONS OF ANADROMOUS FISHES IN VIRGINIA RIVERS.** Michael C. Odom, Richard J. Neves, and John J. Ney, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. The historic and present extent of upstream migrations of striped bass, American shad, and river herring (alewife and blueback herring) in Virginia's rivers are being determined by reviewing literature, consulting with personnel from natural resource agencies, interviewing local fishermen, and making personal observations during spawning runs. Dams on the Rappahannock and James rivers prevent fish from ascending to once significant spawning grounds, while the Mattaponi and Pamunkey rivers (York River tributaries) lack any anthropogenic barriers to anadromous fish. Tributaries of the lower James (below Richmond) and Potomac rivers have been evaluated. Impediments on their tributary streams include beaver dams, pipeline crossings, dams, and culverts. Stream degradation associated with urbanization appears to have nearly extirpated river herring runs from some Potomac River tributaries in Fairfax and Prince William counties. (Funded by the Va. Transportation Res. Council, Va. Dept. of Transportation)



ESTIMATION OF ALGAL BIOMASS ON THE JAMES RIVER MAINSTEM AT RICHMOND, VA. F. Paul Silverman & Greg C. Garman\*, Aquatic Ecology Lab., Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284 & Barry H. Rosen\*, Dept. of Sci. and Math, Univ. of Tampa, Tampa, Fla. 33606. Periphyton and phytoplankton are being sampled monthly from Oct. 1987 through Sept. 1988 on the James River at Richmond. There are substantial temporal changes in algal community composition, but overall taxonomic richness is relatively constant. The phytoplankton density was greatest in Jan. 1988, (45,750 cells/l), while periphyton was densest in Feb. 1988 ( $9.2 \times 10^6$  cells/m<sup>2</sup>). Total chlorophyll was highest in Jan. 1988 in both the periphyton and phytoplankton communities. Phosphorus and nitrogen concentrations in the water have remained relatively constant throughout the sampling period, except for an influx of phosphate in Nov., possibly the result of agricultural runoff. Community structure may be somewhat correlated with changes in river discharge. (Supported by a grant from the James River Basin Association)

SEASONAL DYNAMICS OF CLADOCERAN AND COPEPOD POPULATIONS OF LAKE JARUN, YUGOSLAVIA, IN RELATION TO ECOLOGICAL FACTORS. Vjera Sostarec, Dept. of Zoology, Univ. of Zagreb, Yugoslavia and Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. The influence of biologically important parameters on the seasonal changes in species composition, abundance, and biomass of crustacean plankton was analyzed in Lake Jarun during 1985. Eleven species of cladocerans have been found in plankton, as well as five species of copepods. Cladocerans that dominated in numbers and biomass were *B. longirostris* in spring, and *D. brachyurum* and *C. quadrangula* in summer. Numbers and biomass of the dominant copepods *Th. dybowskii* and *E. gracilis* varied during the year, but the greatest values were in early autumn. All these species were more abundant at the bottom than on the surface of the lake. Seasonal dynamics of the dominant cladoceran species can be explained by changes in the amount of phytoplankton and temperature, predation of fish, and competition between different species of zooplankton. Biomass of copepods increased in the warm part of the year, but the variation in their quantity cannot be directly connected to ecological factors other than temperature. Analyses of cladoceran and copepod populations, especially of parameters suitable for determination of the trophic state of the lake, show that the number of the species, presence of indicator species, and biomass values (14 - 42 ug/l) are in the limits characteristic for oligotrophic lakes, showing a trend to increase the trophy on some locations in the warm part of the year.

## Geology

PROGRESS IN COMPUTER MODELING OF MINERAL GROWTH IN ROCKS. Roddy V. Amenta, Dept. of Geology & Geography, Robert Bunting, Dept. of Mathematics & Computer Science, Carl G. Droms, Dept. of Mathematics & Computer Science, James Madison University. A computer model is being developed to simulate the growth of minerals in rocks as an alternate experimental method in petrology. Ultimate objectives include modeling processes that result in chemical and physical properties of igneous and metamorphic rock. Immediate objectives are to develop software primitives which perform the following tasks: (1) growth of crystals according to their internal lattice geometries in 2-dimensions, (2) growth of crystals of arbitrary shapes, (3) growth of crystals with fixed or varying chemical compositions, and (4) space arbitration among competing growing crystals. One expected result will be computer generated chemical composition maps for minerals which may be compared to maps obtained from SEM analysis of real crystals.

HEAVY MINERALS IN EASTERN VIRGINIA. C.R. Berquist, Jr., Virginia Division of Mineral Resources, Dept. of Geology, College of William and Mary, Williamsburg, Va. 23185. Beginning in 1985 the Va. Div. of Mineral Resources and the Va. Inst. of Marine Science have cooperated to identify heavy mineral concentrations in sediments beneath offshore Virginia waters. Over 400 samples from surface grabs and vibracores were taken on the continental shelf from Assateague Island to the North Carolina boundary. Sample size was large (average of 20 pounds). With 60% of the samples analyzed, heavy mineral concentrations range from 0.1% to 14.7% with an average of 3.5%. Concentrations of one or more minerals (ilmenite, leucoxene, rutile, monazite, zircon) from 33 samples surpass typical values for economic land-based deposits. In addition to the offshore samples, 10 samples on land from high-level "gravel" deposits along the fall zone were also examined. Heavy mineral concentrations range from 0.2% to 14.6% (average 4.8%). The average concentration for onshore economic minerals is: rutile 4.3%; leucoxene 12.3%; ilmenite 44%; monazite 0.3%; zircon 15.5%. Areas underlain by G1 and G2 shown on the coastal plain map of Virginia have a potential for high mineral concentrations.

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POTENTIAL OIL AND GAS PROSPECTS ALONG THE NORTHWEST EDGES OF THE HUNTER VALLEY/CLINCHPORT THRUST SHEETS, SCOTT CO., VA.. R.N. Diffenbach\* & W.S. Henika\*, Va. Div. of Mineral Resources, Charlottesville, Va. 22903. Recent detailed mapping along the n.w. edges of the Hunter Valley and Clinchport thrust sheets in the East Stone Gap, Fort Blackmore and Dungannon 7.5 ' quads. suggests the presence of at least two closed structural highs. These highs appear to be located beneath the overturned limb of the Stone Mountain syncline along the upturned Hunter Valley thrust. Three lines of evidence based on surficial structure along the Hunter Valley Thrust lead to this conclusion: (1) anomalously n.w.-dipping strata on the upright limb of the Stone Mountain syncline, (2) the locally nearly horizontal axial plane of the syncline, and (3) three linear domains of bedding attitudes on the overturned limb of the syncline that suggest rotation of bedding by underlying arching. Another high has been recognized to be a similar structure hidden beneath the upturned Clinchport thrust in the the s.e. corner of the East Stone Gap quad. Fractured Greenbrier, Berea and Trenton reservoir rocks are probably involved in structures along the Hunter Valley fault, whereas algal dolomite in the lower Knox and sands in the Rome may be productive beneath the Clinchport thrust.

GEOCHEMICAL CHARACTERIZATION OF CORROSIVE SAND FILL MATERIAL, CHESAPEAKE, VA. J. J. Dodson\* and J. H. Rule, Geological Sciences, Old Dominion Univ., Norfolk, VA 23529-0496. Emplacement of an aluminum storm drain system through a previous landfill and subsequently covered with sand from a Chesapeake, VA borrow pit caused the pipe to corrode within four months. The focus of the study was to determine whether corrosion of the pipe could be attributed to the sandfill material, groundwater from the landfill or both. Sand from the borrow pit has unusually low pH values and contains high levels of acidity, sulfates and sulfides. At the site, levels of acidity and sulfate were sharply reduced while the sulfide content decreased by one half. The contribution of the groundwater moving through the landfill into the drain system has only a negligible impact. Oxidation processes occurring within the pit are producing abundant ferric hydroxide precipitates and green yellow sulfate crusts. The source of the acidity and sulfides in the sandfill material is attributed to an organic-rich muddy marsh deposit that locally contains abundant well preserved plant material. Where the muds are present, underlying carbonate shell material has been leached away, but where thin or absent, the shell material is preserved.



A PRELIMINARY REPORT ON THE SEDIMENTOLOGY OF PERCHED HOLOCENE SWAMP DEPOSITS IN THE VALLEY AND RIDGE PROVINCE, GILES COUNTY, VA. K. M. Farrell, Dept. of Geol. Sciences, Old Dominion Univ., Norfolk, Va. 23529, & A. P. Schultz, U.S. Geological Survey, Reston, Va. 22092. A sag pond located in hummocky topography upslope from a giant rock block slide at 2570 ft above M.S.L. on the southeast slope of Brushy Mt. was vibracored and two units were identified. A lower poorly sorted muddy sand with matrix-supported angular rock fragments is overlain by peat with a basal radiocarbon date of  $9860 \pm 250$  B.P. The peat contains narrow tongues of poorly sorted conglomeratic muddy sand. This sequence indicates that 1) the rock block slide occurred prior to Holocene time, 2) a period of intense debris flow activity existed on the slopes after the rock block slide and prior to earliest Holocene time, and 3) a peat bog that has received only periodic incursions of debris flow was established near the beginning of Holocene time and exists to the present.

THE EFFECT OF AGRICULTURAL CHEMICALS ON GROUNDWATER QUALITY NORTHERN SHENANDOAH VALLEY, VIRGINIA. H.G. Goodell and R. LoCastro\*, Dept. Env. Sci., Univ. of Va., Charlottesville, VA 22903. Groundwater samples from 229 sites in Clarke and Frederick counties were analyzed for TDS, pH, hardness, conductivity, heterotrophic bacteria, major cations and anions. Sixty of the localities were analyzed for 11 pesticides. Discriminant analysis was used to construct hydrochemical profiles for groundwaters from the four major aquifer lithologies: Cambro-Ordovician Carbonates, Ordovician Shales, Devonian Clastics, and Precambrian/Cambrian Metamorphics. The Carbonate Aquifer was classified into agricultural and non-agricultural land uses. Student t tests show significantly higher concentrations of  $K^+$ ,  $NO_3^-$  and  $SO_4^{2-}$  for agricultural groundwater samples. Highest nitrogen values are from point sources of manure. The mean  $NO_3^-$  concentration for the Carbonate Aquifer is 8.4 mg/l, ten times higher than the other aquifers. Pesticides were identified in 87% of the samples with insecticides found principally beneath orchards. Herbicides are found under all agricultural land uses. Heterotrophic bacterial counts range up to 14,000 per ml. The Carbonate and Shale Aquifers in Frederick County have bacterial counts over 500 per ml in 62% of the samples, regardless of land use. In Clarke County only 36% of the samples exceed this standard.

CONGLOMERATES IN THE TRIASSIC RICHMOND BASIN, VIRGINIA. Bruce K. Goodwin, Dept. of Geology, Col. of William and Mary, Williamsburg, VA 23185. Six different types of conglomerates occur within the Upper Triassic sedimentary rocks of the Richmond Basin. Each was deposited in a particular environment and at a particular interval of basinal infilling. The six conglomerate types are: (1) basal conglomerate, up to 50 feet thick and containing rounded cobbles and boulders of crystalline rocks; (2) very coarse boulder breccia occurring adjacent to the basin's northwestern margin, containing angular fragments of gneiss and cataclastic rocks up to six feet across in a matrix of sandstone and siltstone, representing talus deposits along a steep escarpment at the basin's western border fault, and deposited contemporaneously with the lower section of the Vinita Beds; (3) intraformational conglomerates occurring as mappable units within sandstones of the Vinita Beds; (4) pebble conglomerates extending basinward from the north-central segment of the basin's western margin deposited along gentler slopes at that margin; (5) fanglomerates containing rounded pebbles and cobbles of igneous and metamorphic rocks deposited in alluvial fans along cross faults cutting the basin's margins; and (6) pebbly, very coarse-grained arkosic sandstones and conglomerates of the Otterdale Sandstone.



ANALYSIS OF THE CRETACEOUS-TERTIARY BOUNDARY AT SIX SITES IN SOUTHERN COLORADO AND NORTHERN NEW MEXICO USING INFRARED ABSORPTION SPECTROSCOPY. John W. Happ, Natural Sciences and Mathematics Division, Shenandoah College, Winchester, VA 22601.

This presentation will summarize the results of an infrared absorption analysis of Cretaceous-Tertiary boundary sites in the Raton Basin in southern Colorado and northern New Mexico.

Key geological layers have characteristic signature infrared spectra which provide an aid in the characterization of the K/T boundary. Analysis of bond vibrational frequencies in the infrared region provides bonding and structural information concerning the components found in the K/T boundary area. Bonding in component silicates changes significantly among the boundary layers and will be described.

SALTWATER INTRUSION AND GROUNDWATER QUALITY IN THE DELMARVA PENINSULA, VIRGINIA. Thomas King\* and H.G. Goodell, Dept. Env. Sci., Univ. of Va., Charlottesville, VA 22903. The current extent of saltwater intrusion in Northampton and Accomac counties on the Delmarva Peninsula has been examined using electromagnetic terrain conductivity (EM). Initial analysis of contoured EM data indicates limited saltwater intrusion on the western margin of the peninsula where salt and brackish water creeks dissect the coast. However, examination of water level and ground water quality records indicates that saltwater intrusion is increasing as groundwater levels decline. In order to determine the amount of potable groundwater lost as the result of saltwater intrusion an empirically derived model relating surface EM response and depth to the 250 mg/l isochlor has been developed. This has been applied to all EM survey locations to provide estimates of the depth to the 250 mg/l isochlor. The 250 mg/l isochlor interface dips more steeply on the Bay side of the Peninsula than on the ocean side and is in excess of 100 meters across its center.

CARBONATE CONCRETIONS USED IN INTERPRETATION OF DEPOSITIONAL CONDITIONS.

Heather Macdonald, Department of Geology, College of William and Mary, Williamsburg, VA 23185. Many exposures of shales and mudstones are poor and sedimentary structures are difficult to recognize. Physical and lithogenic sedimentary structures visible in carbonate concretions are characteristic of those in the enclosing fine-grained sedimentary rocks and provide information on mechanisms of deposition and degree of bottom water anoxia. The Cretaceous Greenhorn Formation in northeast Wyoming is composed of noncalcareous and calcareous shales and mudstones with abundant limestone concretions. Three microfacies of fine-grained sedimentary rocks are recognized in concretions and in core samples. Thinly-laminated shale was deposited by pelagic settling in anaerobic conditions. Laminated and variably bioturbated mudstone and thoroughly bioturbated mudstone units were deposited by pelagic settling in dysaerobic conditions intermittently influenced by currents. The Devonian Millboro Shale in west-central Virginia also contains abundant carbonate concretions. Sedimentary structures preserved in the concretions provide information on depositional conditions in the enclosing shales.

STRATIGRAPHIC ANALYSIS OF THE UPPER PART OF THE MISSISSIPPIAN IN DICKENSON COUNTY. Jack E. Nolde, Va. Div. of Mineral Resources, Abingdon, Virginia 24210.

Upper-most Mississippian strata were correlated in 269 wells in Dickenson County, using gamma ray-density and sample description logs. The strata range from the base of the Little Stone Gap Member of the Hinton Formation to the base of the Pennsylvanian age rocks. The interval comprises a heterogeneous sequence of limestone, shale, siltstone, sandstone, and pebble conglomerate. After constructing structural and isopachous maps, facies maps of limestone, shale, and sandstone distribution were made that included sandstone isolith and trend-surface maps.

Fitting trend surfaces to sandstone thickness allows interpretation of depositional environments. The patterns of positive residuals in second order polynomial trend-surface maps of sandstone thickness permits recognition of deltas and bars.

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#### REMOTE SENSING ASSESSMENT OF NORTHERN VIRGINIA RESOURCES

James V. O'Connor, Dept. of Env. Sci., MS 44-04, Univ. of D.C., 4200 Conn. Ave. NW, Washington, D.C. 20008.

A variety of airborne and subsurface remote sensing data on northern Virginia is available. Types of remote sensing data include images from Landsat, SPOT, SLAR, AVHRR, and U2 systems, or spectral data from radioactivity, gravity, magnetic, and applied seismic studies. Remote sensing is a key tool for seven resource research areas: namely, outlining the geomorphic sub regions for economic resources like crushed stone; establishing the patterns of structural fractures for ground water management; assessing the quality of the Potomac River and Estuary for flow regime, sediment plumes, vegetation blooms, and sonar bottom profiles; plotting urban sprawl rates and sprawl impact on resource supply zones; providing a grand view of infringement on critical environmental areas like Mason Neck, Hybla Valley, or Manassas Battlefield; assisting in realistic searches for underground energy supplies; and supplying a baseline for ground truthing anomalies.

STRUCTURAL VS. STRATIGRAPHIC PARSIMONY: AN EXAMPLE FROM THE TRIASSIC DANVILLE BASIN OF VA.-N.C. Robert E. Weems, MS 928, U.S. Geological Survey, Reston, VA 22092. Parsimony advocates the least number of hypothetical elements to explain or describe the real world. But in the Danville basin, the simplest structural interpretation of the basin dictates that a complex sedimentary sequence exists. A moderate increase in the assumed structural complexity of the basin allows the stratigraphy of the basin to be greatly simplified. Search in two areas where stratigraphic parsimony predicts structural complexity reveals indirect evidence that faulting must be present. In one case, a uniform westward dip angle of about  $45^{\circ}$  to  $50^{\circ}$  suddenly changes to a consistent westward dip of only about  $30^{\circ}$ . In the other case, well laminated laterally persistent lacustrine shales can be followed to a narrow gully. Two hundred feet away, across the gully, the rocks along strike abruptly become pebbly, crossbedded fluvial sandstones. These examples suggest that stratigraphic parsimony may be a more predictive principle in this basin than structural parsimony.

WEATHERING OF QUARTZITE COBBLES IN ALLUVIAL FANS, AUGUSTA COUNTY, CENTRAL VIRGINIA BLUE RIDGE. G. Richard Whittecar and Debra L. F. Duffy, Dept. of Geol. Sci., Old Dominion Univ., Norfolk, Va. 23529. An apron of alluvial fans up to 4 km wide mantles the western toe along much of the Blue Ridge mountains in central Virginia. The fan complex in Augusta County south of Waynesboro contains numerous terrace levels with different degrees of weathering. Extensive exposures in mid-fan locations display mostly braided stream deposits, clast-supported boulder and cobble gravels interbedded with sand sheets, although matrix-supported debris flow-type facies are also present. Two buried paleosols each greater than 3 meters thick indicate extensive alluviation occurred during at least three widely-spaced periods. Relative ages of gravels are quantifiable with a five-point quartzite clast weathering scale developed for this setting. Unit A gravel clasts are very resistant to breakage and have no or only minor weathering rinds. Unit B quartzite clasts behave like moderately to very weakly indurated sandstones due to the removal of quartz cement. Clasts in Unit C gravel beds are nearly or totally incompetent. Geomorphic position, hue and clay content of Bt horizons, and total solum thickness may also prove to be significant criteria for distinguishing relative ages of terrace and fan deposits.

THE EFFECT OF SILURIAN STRATIGRAPHIC CHANGES ON THE DISTRIBUTION OF LARGE, QUATERNARY BEDROCK LANDSLIDES, APPALACHIAN VALLEY AND RIDGE PROVINCE. C. R. Wiggs,\* and A. P. Schultz\* U.S.G.S., 955 National Center, Reston, VA 22092. Large, Quaternary, bedrock landslides are evident on the dip slopes of Silurian rocks in the Appalachian Valley and Ridge province of eastern North America. The majority of these features have been found in a 100-mile-long slide zone near Roanoke, Virginia. In the slide zone, the Silurian rocks consist of 3 distinctive parts, a lower quartzite section, a middle sandstone and shale section, and an upper quartzite and sandstone section. Changes in thickness and facies of the ridge-forming Silurian rocks northwest and southeast of the slide zone appear to control the number and size of dip slope failures. Recognition of the stratigraphic control on the size and distribution of large slope failures is important in evaluating past climatic and seismic triggering events.

## Materials Science

POTENTIAL SCANNING OF CORROSION SITES WITH A COMPUTERIZED EDDY CURRENT DISPLACEMENT MEASUREMENT SYSTEM. Frederic D. Bogar, Naval Research Lab., Code 6322, Washington, D.C., 20375-5000. Computer software and hardware were developed to measure potential profiles in the solution above actively corroding bimetallic coupons. A commercial motorized micromanipulator was adapted for computer control. Distance was precisely measured with an eddy current device whose output was interfaced to the computer. Under the control of the computer, potential profiles were measured against a silver/silver chloride microelectrode. The resultant potential profiles were compared with theoretical calculations from the literature based upon boundary element methods of analysis.



**CREEP AND CREEP RUPTURE IN HIGH TEMPERATURE MA ALUMINUM ALLOYS.** J.K. Briggs, J.A. Hawk and H.G.F. Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. This study is part of a large scale investigation of mechanical and structural properties of high temperature mechanically alloyed (MA) alloys. The focus of this talk is an investigation of creep and creep rupture in mechanically alloyed aluminum-titanium. Experimental data was generated in the form of characteristic creep curves (strain vs. time) in order to determine minimum creep rates for various load and temperature conditions. Load changes were performed when a reasonable strain rate was achieved in order to determine the stress exponent. Creep rupture tests allowed the time-to-failure to be determined for several alloys. SEM examination of creep rupture fracture surfaces provided insight into the high temperature deformation of these alloys.

**CHARACTERIZATION OF OCCLUDED AQUEOUS ENVIRONMENTS IN AL-LI-CU ALLOY 2090.** Rudolph G. Buchheit and Glenn E. Stoner, Department of Materials Science, University of Virginia, Charlottesville, Virginia 22901. Changes in potential and pH occurring in simulated crevices machined in alloy 2090 have been monitored as a function of bulk environment condition and time. In this talk, the methods used for simulating and making measurements of potential and pH in occluded environments will be described. The chemistry developed in crevices formed in 2090 will be compared to that developed in conventional aluminum alloys like 2024 and 7075. The corrosion mechanisms thought to cause the observed potential and pH changes will also be discussed.

**CORRELATION DATA AND ANALYSIS TO ESTIMATE THE CRITICAL SURFACE TENSION OF A SOLID FROM A SINGLE CONTACT ANGLE MEASUREMENT.** K.W. Campbell, C.D. Ross, R.E. Barker, Jr., Dept. of Materials Science, Univ. of Virginia, Charlottesville, VA 22901. A technique is developed in which the unknown critical surface tension of a solid,  $\gamma_c$ , is predicted from measurement of a single contact angle,  $\theta$ , with a chosen liquid. This is accomplished through the correlation of collective data for a number of similar solids of known  $\gamma_c$  and  $\theta$  using a given liquid. Examples of the correlation achieved for a number of polymer/liquid systems are presented graphically and possible causes for the deviation from the predicted ideal behavior are discussed.

**THE INFLUENCE OF MICROSTRUCTURE AND ENVIRONMENT ON THE ANODIC POLARIZATION PERFORMANCE AND PITTING BEHAVIOR OF ALLOY 2090.** Kevin A. Coyne, James P. Moran, Glenn E. Stoner, Dept. of Materials Science, The Univ. of Virginia, Charlottesville VA 22901. The electrochemical properties of Alloy 2090 (Al-Li-Cu) were examined with potentiodynamic and potentiostatic polarization in both aerated and deaerated NaCl. Under-aged and peak-aged tempers were tested. Two types of pitting were observed; grain/subgrain boundary pitting and pitting associated with constituent particles. The concentration of grain/subgrain boundary pitting increased with aging from under-aged to peak-aged, while the constituent particle pitting remained fairly constant. Break-away potentials were more negative for the under-aged temper. The primary effect of deaeration was a significant decrease in the corrosion potential. The breakaway potentials determined potentiostatically showed similar trends, but were slightly more negative than those determined potentiostatically. The results suggest that the under-aged temper is more corrosion resistant than the peak-aged temper.

**INTERNAL LiH FORMATION DURING THERMAL OXIDATION OF Al-Li ALLOYS:**

R.C. Dickenson, K.R. Lawless, Materials Science, Thornton Hall, UVA, Charlottesville, VA 22901, & K. Wefers, Alcoa Technical Center, Alcoa Center, PA 15089. Thermal processing of Al-Li alloys in air leads to the selective oxidation of Li from the alloy, particularly during homogenization and solutionizing. During thermal oxidation, surface reactions between metal atoms and atmospheric moisture can generate hydrogen. Thus, hydrogen diffuses into the alloy from the surface. Once in the alloy, hydrogen can combine with Li to form internal LiH particles. This process is analogous to internal oxidation. A commercial Al-2.8Cu-2.2Li-0.12Zr alloy (2090) oxidized in flowing laboratory air at 550°C showed this behavior. The rate of penetration of the internal hydride zone (IHZ) was approximately linear (75 $\mu$ m/hr) for 7-8 hours, after which the front of the zone approached a limiting depth of 650 $\mu$ m. Concurrently, the internal LiH particles nearest to the metal/oxide interface decomposed to leave a hydride free zone (HFZ). As with the IHZ, the HFZ penetrated into the metal at an initially linear rate (32 $\mu$ m/hr), and after 7-8 hours a limiting thickness (300 $\mu$ m) was approached. These results suggest that phase boundary reactions control the rate of IHZ and HFZ ingress in the linear regime. With increasing oxidation time, the diffusion distances increase sufficiently for bulk diffusion of H and Li to control the rate of ingress of the IHZ and HFZ, respectively. The IHZ and HFZ limiting thicknesses are reached when the penetration rates of these zones equal the velocity of the metal/oxide interface due to the flux of metal atoms into the external scale.

**MICROSTRUCTURAL CHARACTERIZATION OF AN Al-Fe-V-Si ALLOY FOR ELEVATED TEMPERATURE APPLICATIONS,** R.E. Franck and J.A. Hawk, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. Studies show that rapidly solidified Al-Fe-V-Si, containing a high volume fraction of  $\alpha$ -Al<sub>12</sub>(Fe,V)<sub>3</sub>Si, possesses good microstructural stability up to 425°. The improvement in strength is due to the slower coarsening rate of the silicide particles. The high volume fraction of dispersoids (37 v/o) also inhibits recrystallization and grain growth, and thus reduces any loss in strength due to long term, high temperature annealing. In this investigation, anneals were performed at 500, 550 and 600°C for up to 1000 hours. Hardness tests, tensile tests and transmission electron microscopy have been performed to assess the mechanical and microstructural changes induced by the anneals. Hardness and tensile tests have revealed a decline in mechanical strength for annealing temperatures above 500°C. The loss in strength can be correlated to changes in the microstructure, where grain growth and particle coarsening have occurred.

**CONDUCTION IN BBL AND PPBT FIBERS.** J.A. Hawk and R.E. Barker, Jr., Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. Electrical conductivity was studied in benzimidazo benzophenathrolin (BBL) and polyparaphenylene benzobisthiazole (PPBT) fibers under a variety of experimental conditions. Specifically, current versus temperature and current versus time measurements were made on these polymers when doped with metal salts (e.g. LiCl, NaCl, etc.), organic liquids (e.g. n-pentane, phenol, etc.) and charge transfer complexes (e.g. iodine). The effect of moisture on the conductivity in these fibers was also explored. In general BBL exhibited electronic conduction with a conductivity of 10<sup>-6</sup> S/m. PPBT showed signs of ionic behavior and possessed a room temperature conductivity of 10<sup>-10</sup> S/m. Moisture sorption produced significant increases in conductivity for PPBT while having only a minor effect on BBL. The effect of dopants on the conductivity was more pronounced at elevated temperatures. For example, doping produced only minor differences in the conductivity at room temperature, but produced significant differences in the measured activation energy for conduction.



RECRYSTALLIZATION AND GRAIN GROWTH IN MA ALUMINUM ALLOYS. J.A. Hawk and R.E. Franck, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. Mechanically alloyed (MA) aluminum possesses a small grained ( $< 0.5 \mu\text{m}$ ) microstructure stabilized by oxide ( $\text{Al}_2\text{O}_3$  and  $\text{Y}_2\text{O}_3$ ) and carbide ( $\text{Al}_4\text{C}_3$ ) dispersoids. These dispersoids tend to be distributed randomly along grain boundaries and effectively inhibit both recrystallization and grain growth. Vickers hardness measurements of MA aluminum, both as-received and after deformation (i.e., cold-rolled), show little indication of softening of the material which is characteristic of a recrystallized structure. Transmission electron microscopy (TEM) has confirmed this result; that is, regions of recrystallized material with significant grain growth have not been observed. It will also be shown that the as-received microstructure in MA alloys should be stable and that the fine dispersion of particles is very effective in maintaining the small grain size in these alloys for any annealing conditions.

ANALYSIS OF STRESS FIELDS IN TWO PHASE ALLOYS (HARD PARTICLES IN SOFT MATRIX) USING FINITE ELEMENT ANALYSIS. S.D. Hollo and J.A. Hawk, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. Mechanical alloyed aluminum-titanium possesses a microstructure that consists of 100-200 nm diameter  $\text{Al}_3\text{Ti}$  grains in an aluminum matrix of similar grain size. To a first approximation the microstructure can be modeled as a hard phase ( $\text{Al}_3\text{Ti}$ ) in a soft matrix (aluminum). A finite element program is used to analyze the deformation characteristics (i.e., stress and strain distribution) is generated for the case when a constant strain is applied to the element) of this microstructure for various volume fractions of the hard phase and modulus differences between the phases. It is anticipated that the effects of temperature on the deformation of this model structure can also be inferred by making appropriate corrections to the elastic moduli of the constituent phases.

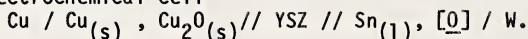
ASHBY-FROST DEFORMATION MECHANISM MAPPING TECHNIQUES. S.D. Hollo and J.A. Hawk, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. A computer program to produce Ashby-type material deformation mechanism maps has been designed and implemented. These maps provide a graphical illustration of the ranges of stress and temperature over which each of 8 different microscopic mechanisms are controlling the rate of deformation of a material. Deformation mechanism maps are produced from semi-empirical equations that give the strain rate due to a mechanism as a function of the applied stress and temperature. The computer program developed uses a numerical search algorithm to solve these equations and simultaneously to determine the locations of the lines and contours that appear on the maps. The program is capable of producing a finished deformation mechanism map from the input material data. The maps will be used as a tool in the investigation of new aluminum alloys.

INTERFACE SHAPE DURING VERTICAL BRIDGMAN GROWTH OF LEAD TIN TELLURIDE.

Yu Huang\*, University of Virginia, Charlottesville, VA 22901 and A. L. Frupp, NASA Langley Research Center, Hampton, VA 23665. A series of quench experiments has been conducted on the  $\text{PbSnTe}$  samples during vertical Bridgman growth. The quench-in interface line can be clearly revealed by electrochemical etching procedures. Electron microprobe data also showed a sharp increase in composition in front of the melt-solid interface. The change in interface convexity as well as interface position are well determined by adjusting the temperature profile.



**ELECTROCHEMICAL VISUALIZATION OF FLUID FLOW IN BRIDGMAN CRYSTAL GROWTH FROM LIQUID TIN.** James H. Hurst\*, Timothy J. Anderson\*, Univ. of Florida, Gainesville, FL 32611, Archibald L. Fripp, Jr., William J. Debnam, Jr.\*, NASA Langley Research Center, Hampton, VA 23665. Convection in liquid tin is visualized with oxygen as a tracer element. The tin is in a cylindrical quartz ampoule in an axial temperature gradient, similar to the Bridgman crystal growth configuration. The oxygen is titrated to and from and detected in the tin through the solid electrolyte yttria-stabilized zirconia (YSZ) in the electrochemical cell



Motion of oxygen in the tin by diffusion and by convection is revealed by the response of one electrochemical cell to an input at another cell. The electrochemical cell flow visualization technique may be extended to other metals and to semiconductor materials. The Henry's law constant for the activity versus concentration of oxygen in liquid tin ( $[\text{O}]$ ), and the Gibb's energy of formation of  $\text{SnO}_2$ , have also been measured with electrochemical cells.

**LANGDON-MOHAMMED DEFORMATION MECHANISM MAPPING FOR THE PERSONAL COMPUTER.** T.A. Johnson and J.A. Hawk, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. A deformation mechanism map is a schematic representation showing which plastic deformation mechanisms are dominant under given conditions of shear stress, grain size and temperature. The common Ashby-type deformation mechanism map requires a large number of calculations and substantial computer memory, and generally is not suitable for use on a personal computer. In the Langdon-Mohammed formulation however, all of the mechanistic boundaries are straight lines which greatly simplifies the number of calculations needed to construct the map. Two-dimensional plots (e.g. shear stress versus temperature for a constant grain size) may be quickly generated on a personal computer. This study involved the construction of an algorithm to not only place boundaries between the dominant mechanisms but to also superimpose contours of constant strain-rate on the map.

**MECHANICAL PROPERTIES OF CAST ALUMINA FIBER REINFORCED ALUMINUM** Coleman Jones, F.E. Wawner. Dept of Materials Science, Thornton Hall, University of Va., Charlottesville, Va. 22903. The addition of ceramic fiber, flake, or particle reinforcement to a metal can significantly increase its strength, modulus, and wear resistance. Metal matrix composites are presently made using powder metallurgy or diffusion bonding processes; the use of the compocasting technique should appreciably lower the costs of these systems. Experiments have been done where milled alumina fibers were added to a vigorously agitated liquid-solid aluminum alloy slurries. The resulting composites were then cast. The cast microstructure is examined and room and elevated temperature tensile test data are presented. Dendritic segregation, viscosity, porosity, and the role of the matrix alloy are also discussed. (Supported by the General Motors Corporation).

AN ELECTROCHEMICAL INVESTIGATION OF AUSTENITIC STAINLESS STEEL ALLOYS IN AGGRESSIVE CHLORIDE ENVIRONMENTS. Karen J. Knueppel\*, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901, & S.R. Taylor, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901. The potentiodynamic polarization technique was used to characterize the pitting and open circuit corrosion behavior of six austenitic stainless steels: Inconel 600, Incoloy 800, Thyssen 1.4571, and 316L, 310, and 304 Stainless Steels. In order to simulate a specific industrial process, the alloys were tested in 3.5 weight percent NaCl solution at 70°C with helium and carbon dioxide purge gases. The potentiodynamic polarization studies indicate that CO<sub>2</sub> has the affect of lowering the pitting potential and increasing the open circuit corrosion potential. Thus, CO<sub>2</sub> addition decreases the potential range of the passive region. Thyssen 1.4571 has been identified as the most suitable candidate for the industrial process based on its high pitting potential and large passive region. The remaining alloys can be ranked according to pitting resistance: Incoloy 800, 316L, 310, and 304 Stainless Steels, with Inconel 600 as the worst candidate.

THERMAL STUDY OF CONVECTION IN LOW PRANDTL NUMBER LIQUIDS. David J. Knuteson and R. Narayanan, Dept. of Chemical Engineering, University of Florida, Gainesville, FL 32611 and A. L. Fripp, NASA Langley Research Center, Hampton, VA 23665. During directional solidification, the melt can undergo several transitions from one flow regime to another. Crystal quality is strongly dependent on the flow regime of the liquid phase during growth. The type of flow in a liquid depends on the strength of the driving force (e.g., a temperature gradient). If there is no convective driving force, the liquid is stagnant. When a sufficient unstable gradient is applied, laminar flow develops. Larger gradients will produce oscillatory and then turbulent convection. Past techniques for identifying convective states are based on visual observation. These methods do not work for opaque, high melting metals and semiconductors. Results from a technique using thermocouple measurements and Fourier analysis will be presented and will delineate the oscillatory and turbulent regions for tin heated from below.

**DENDRITIC SEGREGATION IN PARTICLE-REINFORCED CAST ALUMINUM COMPOSITES** John W. McCoy and F.E. Wawner Jr. *Materials Science Dept. University of Virginia, Charlottesville, VA 22901.* An apparatus was built for dispersing ceramic particles into semi-liquid aluminum to produce metal-matrix composite castings. A variety of reinforcing material and matrix alloy combinations were prepared. It was observed that even though reinforcing particles may be wetted and uniformly dispersed in a liquid metal, they can become segregated into dendrite interstices during solidification. In some cases, this segregation causes severe agglomeration and interparticle contact, but in others, it is not observed at all.

In this study, a set of experiments was performed to determine what combinations of factors produce this effect. A matrix alloy of Al-3Mg was used in combination with particles of SiC, B<sub>4</sub>C, TiB<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, and ZrB<sub>2</sub>. Particle size was varied between 3 and 25 microns. A mold was designed which produced a range of secondary DAS between 5 and 50 microns. The composites cast in this mold were sectioned, polished and photographed in an SEM. The photographs were digitized into a computer, and the inter-particle spacings were statistically analyzed. The results indicate wide variations in segregation behavior among different types of particles, probably due to differences in particle/solid contact angle. Segregation is most severe at the lower end of the particle size range studied, and at the upper end of the DAS range studied.



**MICROSTRUCTURAL AND ENVIRONMENTAL EFFECTS ON THE STRESS CORROSION CRACKING BEHAVIOR OF ALLOY 2090.** James P. Moran, Glenn E Stoner, Dept. of Materials Science, The Univ. of Virginia, Charlottesville VA 22901. The Stress Corrosion Cracking (SCC) behavior of Alloy 2090 has been studied using two techniques; constant extension rate (CERT) testing and constantly immersed, constant strain testing. The CERT experiments were performed in NaCl. The effects of aging, applied potential and strain rate were examined. The results suggest that SCC occurs only above a particular potential, and that this potential changes with aging. The potentials required for SCC are near the pitting potential. The constant strain experiments were performed in NaCl-based environments, with various cation and anion additions, including sodium, lithium, and carbonate ions. The results reveal that modest changes to the bulk environment can have a significant effect on the SCC behavior of 2090. In addition, these environmental effects appear to be more significant, relative to microstructural effects due to aging.

**COMPARISON OF MANY-BODY POTENTIALS FROM THE EMBEDDED ATOM METHOD WITH TRADITIONAL PAIR POTENTIALS IN METALS.** Dirk J. Oh\* & Robert A. Johnson, Dept. of Materials Science, University of Virginia, Charlottesville, Va. 22901. The embedded atom method (EAM) is a technique for the construction of many-body potentials for metals that has been developed recently at Sandia National Laboratory. In this talk, EAM is briefly explained and compared with traditional pair potentials. A simple exponential model, proposed by Johnson, is chosen to demonstrate EAM. (Supported by DOE Grant DE-FG05-86ER45246)

**PREDICTION OF SLIP-BAND FACET ANGLE IN THE FATIGUE CRACK GROWTH OF AN Al-Li ALLOY:** P. S. Pao, M. A. Imam, L. A. Cooley, and G. R. Yoder, Naval Research Laboratory, Washington, DC 20375-5000

Aluminum-lithium alloys exhibit uncommonly good resistance to the growth of fatigue cracks over a broad spectrum of stress-intensity range --- when compared to conventional 2000 and 7000-series aluminum alloys. Though it has been suggested that this superior resistance is a consequence of enhanced crack closure levels, there is little understanding of the microstructural origins of the fatigue crack growth process in these alloys, which involves the development of extraordinary surface roughness. Preliminary results indicate that crystallographic texture plays an important role in the cracking process. This work illustrates not only that slip-band facet and asperity angles in the fatigue crack growth profile can be predicted from the texture, but suggests that the unusual height of asperities in the fatigue fracture surface develops as a consequence of extraordinary intensity of the texture, so that an individual shear facet can readily traverse several grains in concert.

**MICROSTRUCTURE AND STRENGTH OF HIGH-TEMPERATURE ALUMINUM COMPOSITES.** William Pollock\* and Frank Wawner, Dept. of Material Science, Univ. of Va., Charlottesville, VA. 22901. High temperature dispersion strengthened aluminum alloys made by rapid solidification were reinforced with fibers and whiskers. The matrix was Al-8Fe-2Mo made by Alcoa. The two types of reinforcement were: Saffil fibers (aluminum oxide) that was coated with Cobalt by Boeing's proprietary sol gel process and SiC whiskers. These composites were studied for their high temperature properties. The resulting fracture surface characteristics related to the strength of the composite at various temperatures. The strengths and fracture surfaces were then compared to conventional aluminum alloys which were reinforced.



MERCURY EMBRITTLEMENT OF AN ALUMINUM-5% COPPER ALLOY. Anthony P. Reynolds\* Dept. of Mat. Sci., U. of Va., Charlottesville, Va. 22901. Aluminum-5% Copper alloys tensile tested in mercury exhibit reduced tensile strength and reduced elongation to failure. The alloy used in this study was tested in two conditions; super-saturated solid solution and overaged. When tensile tested in air the solid solution alloy failed by microvoid coalescence (MVC), the overaged alloy failed by a combination of MVC and intergranular ductile failure. When tensile tested in mercury the solid solution alloy failed predominantly by transgranular "cleavage" accompanied by some brittle grain boundary failure. The overaged alloy failed almost exclusively by a brittle intergranular mechanism. Indirect evidence suggests that the cleavage is crystallographic in nature and may occur on {100} crystal planes. Evidence is provided by etch pit studies and secondary crack morphology. Failure in the overaged alloy appears to occur along precipitate/matrix interfaces.

A STUDY OF THE EFFECTS OF HOT ROLLING ON DISCONTINUOUSLY REINFORCED AL ALLOYS. Randy Schueller\* and Frank Wawner, Dept. of Material Science, Univ. of Virginia, Charlottesville, VA 22901. Effects of hot rolling on Al2124 15% SiC whisker composite was examined. A sheet of rolled composite (SXA24) was received from a commercial source. This material was tensile tested and studied with the scanning electron microscope in both the as received condition and after heat treatment (T-6). It was found that rolling significantly weakens a composite mainly by overaging it. Large precipitates form and much of the composite strength is lost, due to a subsequent decrease in matrix shear strength and also due to the brittle precipitates creating large voids and thus low energy crack paths. These precipitates are dispersed during the heat treatment and the composite strength is regained.

AN ELECTROCHEMICAL INVESTIGATION OF THE CORROSION PROPERTIES OF HIGH STRENGTH AUSTENITIC STAINLESS STEELS IN HOT CHLORIDE ENVIRONMENTS. Kevin J. Stoner\*, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22903, & Dr. R.P. Gangloff, Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22903. The electrochemical behavior of five alloy steels: 304L, 316L, and 317L Stainless Steel, A286, and Inconel 718 were investigated. ASTM standard G5-82 polarization technique was used to determine the pitting and open circuit corrosion behavior of these five alloy systems in various weight percent NaCl solutions at 90°C. Environmental variables such as solution pH, temperature, oxygen and hydrogen sulfide content were also investigated. Inconel 718, a precipitation hardened nickel-base superalloy was tested in a variety of heat treatments. Initial polarization findings showed little effect of microstructure on the pitting behavior of this alloy system, although its mechanical properties vary with heat treatment. This work is being done to help understand the stress corrosion cracking behavior of these alloys.

## Medical Sciences

RECONSTITUTION OF ACTINOMYCES Mn-CONTAINING SUPEROXIDE DISMUTASE. K. B. Barkley and E. M. Gregory, Dept. of Biochem. and Nutr., Va. Tech, Blacksburg, VA 24061. Anaerobically maintained Actinomyces odontolyticus produced a Mn-containing superoxide dismutase (MnSOD). The enzyme was purified 100-fold from crude extract with 30% yield by two chemical fractionations and three chromatography steps. The protein,  $M_r$  95,000 was a tetramer composed of noncovalently associated subunits of equal size. A preparation whose specific activity was 800 U/mg had 1.4 g-atoms Mn and <0.40 g-atoms Fe per mole enzyme. Exposing the enzyme to either 5 M guanidinium chloride, 20 mM 8-hydroxyquinoline (pH 3.2) or 0.2 M  $\text{Na}_2\text{CO}_3$ , 2 mM EDTA (pH 11.0) diminished enzyme activity with a concomitant loss of manganese. Anaerobic dialysis of the denatured protein in buffer containing 1.2 mM  $\text{MnCl}_2$  restored  $\text{O}_2^-$ -scavenging activity. Reconstitution of the MnSOD utilizing the alkaline (0.2 M  $\text{Na}_2\text{CO}_3$ ) method, resulted in a 1.6 - 3.5 fold increase in specific activity compared with the isolated enzyme. The native and Mn-reconstituted SODs were inhibited 35% by 20 mM  $\text{NaN}_3$ , migrated identically in 10% acrylamide gels, and focussed to isoelectric points of 4.6. Supported in part by Grant AI 15250 from the National Institute of Health.

PEROXIDATION OF COPPER-ZINC SUPEROXIDE DISMUTASE: RATE ENHANCEMENT BY CYANIDE. Martha M. Bolton and E. M. Gregory, Dept. of Biochem. and Nutr., Va. Tech, Blacksburg, VA 24061. The Cu/Zn-containing superoxide dismutase from bovine erythrocytes is irreversibly inactivated upon exposure to  $\text{H}_2\text{O}_2$  (1) but addition of cyanide increased the rate of peroxidation. The increased rate was dependent upon the concentration of cyanide. At constant enzyme concentration (50 U/mL, 15 micrograms /mL) and 2.5 mM  $\text{H}_2\text{O}_2$ , the time for 50% inactivation was 10.5, 7.0, 6.3, and 3.0 min. with 0, 0.5, 1.0, and 5.0 mM cyanide respectively. The peroxidized enzyme migrated more rapidly and as a more diffuse band in 7.5% acrylamide gels than did the control superoxide dismutase. The native and peroxidized enzymes were focussed to their isoelectric points in acrylamide gels containing ampholytes. The native enzyme focussed to a major band at pH 5.1 and a minor band at pH 5.0. The peroxidized enzyme displayed 3-4 bands which were more acidic than the native enzyme. Azide (10 mM) completely protected the enzyme from peroxidation in the absence but not the presence of cyanide. (1) Hodgson, E.K. and I. Fridovich, Biochem. 14:5294-5299, 1975. Supported in part by Grant AI15250 from Nat. Inst. Health and J104 from the Jeffress Trust.

CHARACTERIZATION OF COCAINE FREE BASE SMOKE. Joseph P. Boni\*, Louis P. Lue and Billy R. Martin, Department of Pharmacology and Toxicology, Va. Commonwealth Univ., Richmond, Va. 23298-0613.

Little work has addressed the quantitative aspects of cocaine FB under pyrolysis conditions. An apparatus was constructed that allows for volatilization and characterization of cocaine FB containing tritiated cocaine (1  $\mu\text{Ci}/50$  mg). Pyrolytic products recovered after a twelve minute volatilization period at varying flow rates and temperatures were limited to benzoic acid (BA), methylecgonidine (MEG) and cocaine. As measured by liquid scintillation, percentage radioactivity recovered ( $n=4$ ) at 260°C and flow rate of 400 ml/min was 34.1% from the pipe, 37.6 % in the glass wool trap and <0.1% in ethanol, 1.0N sulfuric acid and 1.0N sodium hydroxide traps respectively. Regional recoveries were 1.4%, 5.8%, <0.1% for BA, 2.8%, 2.4%, <0.1% for MEG and 25.4%, 60.7%, <0.1% for cocaine at these sites respectively. Flow rate and temperature are shown to greatly affect the degree of volatilization and pyrolysis profile obtained. Highly variable peak concentrations of cocaine occurred within the first 1.5 minutes of heating. This variability is shown to increase with increased flow rate before reaching steady-state levels (from 2-12 minutes). Therefore, smoking modalities that maximize initial volatilization lead to highly variable concentrations of parent cocaine in the mainstream smoke while minimizing its pyrolysis. (Supported by NIDA DA-02396).



**DOES  $\beta$ -CAROTENE PREVENT ADRIAMYCIN TOXICITY?** R.B. Brandt, J.D. NUCKOLS\* & M. FENSTER\*, Dept. of Biochem. & the Massey Cancer Center, MCV/VCU, Richmond, VA 23298. Adriamycin (Adr) is an effective antineoplastic agent, although its cardiotoxicity limits use. A possible cause of the toxicity is the formation of free radicals from the quinone portion of Adr. The use of scavengers, particularly those that may be incorporated in the diet such as  $\beta$ -carotene (BC) may provide protection against Adr damage. Mice were fed 0.4% BC beadlets or placebo beadlets (Hoffman-LaRoche) for one year and the concentration of retinoids and carotenoids were determined by simultaneous HPLC methodology. Specific -SH enzymes (glyceraldehyde-3-P dehydrogenase (GAPDH) and isocitrate dehydrogenase (ICDH)) were determined in heart homogenates treated *in vitro* with 0-150  $\mu$ M Adr. Inhibition of GAPDH, was less for the BC treated mice, while ICDH values were similar to that in the placebo mice. BC was found in adipose tissue, brain, kidney, heart, lung and muscle for the BC treated, but only in kidney for the placebo mice. Only liver and adipose tissue showed retinoids, with no difference between BC or placebo fed mice. (Supported by funds from the United Cancer Council).

**DEVELOPMENT OF AN HPLC METHOD FOR DETERMINATION OF PENTOBARBITAL N-GLUCOSIDES (PTBNG) IN HUMAN URINE.** Gerald C. Capps and P.J. Soine, Chem. Dept., Randolph-Macon Col., Ashland, Va. 23005, T.M. England and W.H. Soine, Dept. of Med. Chem., VCU, Richmond, Va. 23298. It has been proposed that humans N-glucosylate pentobarbital (PTB) following oral administration. When glucose is coupled to PTB four diastereomers are possible. HPLC methods have been developed to detect and quantitate all four diastereomers. Relative to analysis for other barbiturate N-glucosides, significant modification of mobile phase and extraction procedures were necessary to reduce interferences present in urine for the PTBNG. Following oral administration of 100 mg sodium PTB, PTBNG were detected in the urine for over two days. The PTBNG were isolated from the urine and characterized against synthetic standards using thermospray LC/MS and post-column derivatization. Significant product enantioselectivity was observed in the urinary excretion of the glucosides of PTB. (Supported by NIH Grant GM34507)

**EVALUATION OF INDOLEALKYLAMINES DESIGNED TO PROBE A HYDROPHOBIC SITE ON SEROTONIN RECEPTORS.** C. S. Chaurasia\*, R. A. Glennon\*, Dept. of Med. Chem., MCV/VCU, Richmond, Va. 23298. Introduction of halo or small alkyl groups at the 4-position of 1-(2,5-dimethoxyphenyl)-2-aminopropane increases both affinity and selectivity of these phenalkylamine(PAA) analogs for 5-HT<sub>2</sub> receptors. This effect may be related to hydrophobic interaction of these 4-substituents. Structure activity studies indicate similarities between indolealkylamines(IAA) and PAA in their modes of binding at 5-HT<sub>2</sub> receptors. The 4-position of PAA may correspond either to the 7- or 1- position of IAA. In an attempt to further understand the mode of binding and the nature of the hydrophobic region, several 7- or 1-alkyl substituted  $\alpha$ -methyltryptamines( $\alpha$ -MeT) were synthesized. Binding affinities of 7-amyl- $\alpha$ -MeT(Ki=210nM), 1-amyl- $\alpha$ -MeT (Ki=155 nM), 7-propyl- $\alpha$ -MeT(Ki=1160nM) and 1-propyl- $\alpha$ -MeT(Ki=1040nM) in comparison to that of  $\alpha$ -MeT(Ki=2500nM) do not support or refute the existence of a hydrophobic site corresponding to the 7-and/or 1-position of IAA or the existence of a common hydrophobic region. Further studies are required to understand the mode of binding.



PROGRESS REPORT ON SPECTRAL ANALYSIS OF BLOOD PLASMA AND SERUM. Germille Colmano, Dept. of Veterinary Biosciences, VPI & SU, Blacksburg, VA 24061. From a data base of 690 spectral absorbances of human blood plasma and serum we selected 15 wavelengths, at nm: 190, 205, 230, 255, 260, 278, 340, 375, 414, 452, 578, 485, 540, 610, 630. From the above we selected 167 cases from 3 pathological groups (20 heart, 21 ulcer, and 20 stomach cancer patients), and 2 physiologically and clinically normal control groups (89 females, 17 pregnant). All groups had a F test with  $P < 0.015$ . By stepwise canonical discriminant analysis 69.82% grouped cases were correctly classified with a predicted group membership of: 61.9% heart, 52.4 % ulcer, 61.9% stomach cancer, 77.5% females, 70.6% pregnant. A rejection of wavelengths between 375nm and 630nm indicated that the lower, ultraviolet absorbance region (between 190nm and 340 nm) may be sufficient for significant group separation. Using these UV absorbances the 47.31% grouped cases were correctly classified, with a predicted group membership of: 61.9 heart, 35% ulcer, 55% stomach cancer, 40.4% females, 70.6% pregnant. We postulate that the lower UV part of the absorbance region is an unexplored region that should be further investigated for separating physiological from pathological conditions.

<sup>3</sup>H-BREMAZOCINE BINDING TO ADULT AND FETAL RAT BRAINS AND TO PLACENTA. B.R. Conway\*, F. Fan\* and B.R. Martin. Dept. Pharmacol. & Toxicol., MCV/VCU, Richmond, Va. 23298. Chronic exposure to drugs of abuse in utero can result in abnormal development and behavior in newborns. Preliminary studies suggest that opioid and catecholaminergic receptors in human placenta are altered by drug exposure. Characterization of the opioid binding sites in control as well as drug-treated adult rat whole brain, fetal brain, and in particular, the placenta, may determine whether the placenta can serve as a useful marker for these developmental changes. Standard radioligand binding methods using <sup>3</sup>H-naloxone, a mu antagonist, and <sup>3</sup>H-bremazocine, a kappa agonist, were employed. In control rats, Scatchard analysis of <sup>3</sup>H-naloxone binding in adult whole brain and fetal brain revealed similar binding affinities ( $K_D = 0.97$  nM and 2.0 nM, respectively) as well as total binding sites ( $B_{max} = 17.6$  and 18.4 pmoles/mg protein, respectively). No detectable binding was observed in whole placenta. <sup>3</sup>H-Bremazocine binding affinities in adult and fetal brains were also similar ( $K_D = 1.09$  nM and 0.70 nM respectively) whereas the total number of binding sites were 983 and 506 fmoles/mg protein. Again, there was no discernable placental binding. It does not appear that measurement of opioid receptors in whole placenta can be used to predict receptor changes in fetal brain. Supported by the Virginia Commonwealth Center on Drug Abuse.

SEPARATION OF TUMORICIDAL AND AMOEBOCIDAL ACTIVITY OF ACTIVATED MACROPHAGE POPULATIONS. K. Fischer-Stenger, G. Cabral and F. Marclano-Cabral, Dept. of Micro./Immunol., Va. Commonwealth Univ., Richmond, Va. 23298-0678. Conditioned medium (CM) from lipopolysaccharide-stimulated cultures of mouse peritoneal macrophages (M $\phi$ ) activated in vivo with Bacille Calmette Guerin (BCG) or Corvnebacterium parvum mediates cytolysis of tumor cells and Naegleria fowleri amoebae. CM from BCG and C. parvum activated M $\phi$  and the RAW264.7 M $\phi$  cell line was assayed for tumoricidal and amoebicidal activity. Cytolytic activity was measured by release of radiolabel from <sup>111</sup>Indium-oxine-labeled L929 tumor cells or N. fowleri amoebae after a 20 hour incubation with M $\phi$  CM. CM from RAW264.7 cells contains tumoricidal activity but not amoebicidal activity. CM from BCG and C. parvum activated M $\phi$  contains tumoricidal and amoebicidal activity. The protease inhibitor, soybean trypsin inhibitor, decreases tumoricidal activity but not amoebicidal activity in activated M $\phi$  CM. Recombinant murine tumor necrosis factor (TNF) or purified human TNF lyses L929 tumor cells but not N. fowleri amoebae. Anti-TNF rabbit serum inhibits tumoricidal activity found in RAW264.7, BCG and C. parvum CM. The antiserum reduces amoebicidal activity in BCG CM but not in C. parvum CM. These results suggest that neither cytolytic protease nor TNF alone is responsible for M $\phi$  amoebicidal activity.

USE OF NMR SHIFT REAGENTS TO STUDY THE METABOLISM OF BARBITUATES. Ruth M. Graham\*, S.M. Mongrain\*, W.H. Soine, Dept. of Med. Chem., Va. Commonwealth Univ., Richmond, Va. 23298, & P.J. Soine, Dept. of Chem., Randolph-Macon Col., Ashland, Va. 23005. Lanthanide shift reagents have proven to be a useful method for simplifying the  $^1\text{H}$ -NMR spectra of barbiturates. A synthetic by-product present in commercially available sodium amobarbital was identified as 5-ethyl-5-(2-methylbutyl)barbituric acid using  $\text{Eu}(\text{fod})_3$  with homonuclear decoupling and EI mass spectrometry. Attempts to use  $\text{Eu}(\text{fod})_3$  to simplify the  $^1\text{H}$ -NMR spectra of the tetracetyl phenobarbital N-glucosides (PBGA) were unsuccessful. Chiral  $\text{Eu}(\text{hfbic})_3$  is useful in determining optical purity of N-methylbarbiturates. Therefore, PBGA was treated with diazomethane followed by oxidative removal of glucose to give R(-)-mephobarbital.  $\text{Eu}(\text{hfbic})_3$  indicated that a single enantiomer of mephobarbital was present. This technique is very useful for differentiating modifications on the alkyl side chain and for determining the optical purity of N-methyl barbiturates. (Supported by NIH grant GM 34507)

LOW MOLECULAR WEIGHT SUPEROXIDE DISMUTASES FROM BOVINE HEART. Adnan I. Ismaiel, J. Y. Juan, and E. M. Gregory, Dept. of Biochem. and Nutr., Va. Tech, Blacksburg, VA 24061. Extracts of bovine heart muscle contained heat-stable components with superoxide dismuting activity in addition to the large molecular weight heat-labile superoxide dismutases. The heat-stable components remained in the aqueous phase during chloroform-methanol (Folch) extraction and eluted from Bio-gel P-2 in the 1000-1500 mol. wt. range. Electrophoretic separation of the fraction from P-2 revealed two bands of activity each coincident with a protein band when gels were stained either for superoxide dismutase activity or for protein. The catalytic activity was not inhibited by either EDTA (1 mM), azide (5 mM) or cyanide (5 mM). The fraction from P-2 also contained a component that expressed superoxide dismuting activity only upon addition of copper or manganese but not iron to the assay. The metal-dependent activity was inhibited 50% upon addition of 1 micromolar EDTA or 175 micromolar azide. The metal-dependent fraction was further separated on a 50 X 2.5 cm P-2 into two components. The larger molecular weight fraction bound to DE 53 in 5 mM potassium phosphate whereas the lower molecular weight component eluted isocratically from DE 53. Supported in part by Grant GM 38548 from the Nat. Inst. of Health.

OPIATE-SEROTONIN SYNERGISM STIMULATING LUTEINIZING HORMONE RELEASE IN ESTROGEN-PROGESTERONE-PRIMED OVARIECTOMIZED RATS: MEDIATION BY  $5\text{HT}_2$  RECEPTORS. James H. Johnson, Susan E. Lenahan\* and Hugo R. Seibel, Department of Anatomy, Med. Col. of Virginia, Richmond, VA 23298. Tonic inhibition of luteinizing hormone (LH) release is seen after giving opiate antagonists to ovariectomized (OVX) estrogen-progesterone-primed rats. In the presence of a serotonin (5HT) agonist, morphine stimulates LH release in OVX rats. In the present study, the individual effects and interactions of morphine and the 5HT agonist quipazine have been studied and challenged using the receptor antagonists ketanserin ( $5\text{HT}_2$ ) and methysergide ( $5\text{HT}_1$  and  $5\text{HT}_2$ ). Rats OVX 2-4 weeks were primed with estradiol benzoate (15  $\mu\text{g}$ ; day 0) and progesterone (5 mg; day 2). Serial blood samples were collected from unrestrained rats via a jugular cannula and plasma LH was measured by RIA. Neither morphine (4 mg sulfate) nor quipazine (2 mg/kg) iv at 12:00 significantly elevated plasma LH at 12:10, 12:20 or 12:30 compared to levels at 12:00. However, injection of both morphine and quipazine at 12:00 greatly augmented LH release at 12:10, 12:20 and 12:30 compared to the response to either drug alone. The duration of the elevation of plasma LH was limited to 10 min by ketanserin (2.5 mg/kg ip at 09:00) and to 20 min by methysergide (10 mg/kg ip at 09:00), suggesting mediation of this response by  $5\text{HT}_2$  receptors. These results suggest the possibility of an important interaction between opiate and 5HT systems in controlling the release of LH, and raise the intriguing question of its role in controlling events of the estrous cycle. (Supported by grant HD 12165).



ROLE OF GLUTATHIONE IN THE INDUCTION OF A STRESS PROTEIN BY THIOL-REACTIVE AGENTS. C.L. Jones and K.R. Shelton, Dept. of Biochem. & Mol. Biophy., MCV-VCU, Richmond, Va. 23298. We have studied the induction of a stress protein, termed SH 30, by a wide variety of chemical inducers and propose a model wherein induction is signaled by modification of a non-glutathione, thiol target molecule. The data indicate that SH 30 inducers can be divided into three classes. The first class contains well known thiol-reactive agents such as 1-chloro-2,4-dinitrobenzene and arsenite. The effectiveness of these inducers is increased as glutathione (GSH) is decreased by prior incubation of the cells with buthionine sulfoximine, an inhibitor of GSH synthesis. The second class comprises chemical inducers of oxidized glutathione (GSSG) such as dithizone, which are less sensitive to GSH levels. In the third class are agents such as t-butyl hydroperoxide and disulfiram which can either react with thiol groups directly or generate GSSG. These data implicate a sensitive thiol group, normally shielded in the cell by high levels of GSH, as a possible target in the mechanism of SH 30 induction.

BIOBEHAVIORAL CONSEQUENCES OF SUSTAINED HIGH BLOOD PRESSURE: EFFECTS OF AGE & DURATION OF ILLNESS. H.E. King, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. The effects of age & duration of hypertensive (HT) illness on behavioral measures probing cognitive, psychomotor, & sensory-perceptual abilities was examined for 100 medicated HT patients between 20-65 years old & 80 matched normotensive (NT) controls. A significant main effect of age was observed (ANOVA) on all performance measures in both NT and HT groups, older subjects being slower in psychomotor speed & performing at a lower level on cognitive tasks. Blood pressure also revealed a main effect, performance by HT subjects falling significantly below NT controls in both younger and older patient groups. Further dividing the subject-pool into subgroups yields cells still too small for reliable statistical definition. Trends in the data suggest that illness-duration exerts a deleterious effect on behavior beyond that of normal aging, & central-acting agents (alpha agonists) can be distinguished from those with peripheral action (beta blockers). Diuretics, which act primarily peripherally, appear to exert a central influence as well, possibly by changes in electrolytes within the brain which may impact on performance.

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GLOBAL ISCHEMIA AFFECTS THE CALCIUM RELEASE CHANNEL OF CARDIAC SARCOPLASMIC RETICULUM. Wendy R. LeBolt, N.H. Manson\*, J.J. Feher\* Dept. of Physiology, Medical College of Virginia, Richmond, VA 23298. The specific character of the ischemic damage to the sarcoplasmic reticulum (SR) has not yet been identified. We assayed SR function after various periods of global ischemia by the oxalate-supported calcium uptake rate of rat whole heart homogenates. This assay was performed in the presence and absence of ryanodine, a plant alkaloid which specifically blocks the calcium release channel. Ischemia was produced in both a Langendorff and in situ preparation. Global ischemia of 10 minutes or more imposed in either model caused a statistically significant depression of calcium uptake rate measured in the absence of ryanodine. The similar effect of ischemia produced in the two models suggests that blood-borne elements are not responsible for ischemic damage. The depression in calcium uptake rate was not observed when ryanodine was not present in the assay medium. This result suggests that the calcium ATPase and permeability barrier of the SR membrane are not affected by ischemia, but the calcium release channel is opened after ischemia. This effect is long-lived as it was not reversed by exposure to the normal preincubation and assay conditions. (Supported by NIH grant HL34681.)



**BEHAVIORAL EFFECTS OF STEREOISOMERS OF CANNABINOID ANALOGS IN MICE.** P. J. Little, D. R. Compton, M. R. Johnson\* and B. R. Martin. Dept. of Pharmacol. and Toxicol. Med. Col. Va.-Va. Common. Univ. Richmond, Va. 23298. The mechanisms by which  $\Delta^9$ -THC exerts its pharmacological effects have not been elucidated, the use of structurally related analogs has greatly aided efforts to define these mechanisms. Three enantiomeric pairs of structurally novel cannabinoids were tested following iv administration in the mouse for depression of spontaneous activity and the production of hypothermia, analgesia, and catalepsy. All active enantiomers displayed the same order of potency in the all tests, being most active in depressing spontaneous activity and producing analgesia, and less active in producing hypothermia and catalepsy. The (-)-enantiomers were up to 770 times more potent than  $\Delta^9$ -THC, with enantioselectivity that ranged from 7-2000. Levonantradol was the least potent (-)-enantiomer, with  $ED_{50}$  values between 0.123-1.5 mg/kg. Dextronantradol was inactive. CP 55,940, a bicyclic analog was 5-75 times more potent than  $\Delta^9$ -THC and 30-75 times more potent than the (+)-enantiomer, CP 56,667. CP 56,667 was active in the spontaneous activity and tail-flick procedures under 10 mg/kg. CP 55,244, a tricyclic analog was the most potent with  $ED_{50}$  values of 4-85  $\mu$ g/kg and was 120-2000 times more potent than CP-55,243 the (+)-enantiomer, which decreased spontaneous activity ( $ED_{50}$ = 8 mg/kg). The (+)-enantiomers were unable to attenuate the effects of  $\Delta^9$ -THC (6 mg/kg iv) in the above tests. The high enantioselectivity and potency of these non-classical cannabinoids indicate a highly specific mechanism of action. (Supported by NIDA grants DA-03672, DA-07027 and DA-05330).

**COMPARISON OF *IN VITRO* AND *IN SITU* BINDING OF  $^3H$ -NICOTINE TO RAT BRAIN.** Thomas J. Martin, Sherrill Todd and B. R. Martin. Dept. of Pharmacol. and Toxicol. Med. Col. Va.-Va. Common. Univ. Richmond, Va. 23298. Binding of  $^3H$ -nicotine to rat brain slices has been recently described. A modification of this assay was used to assess  $^3H$ -nicotine binding for structure-activity relationships and compare this technique to standard a *in vitro* assay. Slide-mounted brain slices were prepared as described previously. The slices (20 $\mu$ m) were incubated in  $^3H$ -nicotine for 2 hr on ice in 50 mM phosphate-buffered saline, pH=7.4, followed by four 30 sec rinses in ice-cold buffer. Nonspecific binding was measured in the presence of 100  $\mu$ M nicotine. The slices were then wiped from the slides with filter paper, solubilized, and counted by scintillation spectroscopy.  $^3H$ -Nicotine binding *in situ* displayed high- and low-affinity binding sites with  $K_d$ 's and  $B_{max}$ 's of 2 nM and 67 fmol/mg protein, and 99 nM and 482 fmol/mg protein, respectively.  $^3H$ -Nicotine binding *in vitro* also revealed two binding sites with  $K_d$ 's and  $B_{max}$ 's of 0.9 nM and 12 fmol/mg protein, and 194 nM and 1265 fmol/mg protein, respectively.  $^3H$ -Nicotine binding *in situ* was displaced by (-)cytisine, (-)nicotine, (+)nicotine, and ( $\pm$ )anabasine with  $K_i$ 's of 0.5, 2.5, 41.5, and 93.9 nM, respectively.  $^3H$ -Nicotine binding *in vitro* at was displaced by (-)cytisine, (-)nicotine, and (+)nicotine with  $K_i$ 's of 2.5, 20, and 49.5 nM, respectively. ( $\pm$ )Atropine, bethanechol, and hexamethonium displaced  $^3H$ -nicotine binding *in situ* with  $K_i$ 's of 13.8, 6.4, and 75.6  $\mu$ M, respectively, whereas (-)cotinine, pempidine, and mecamylamine did not displace this binding at concentrations up to 1mM. The assay employed thus yields  $^3H$ -nicotine binding *in situ* comparable to the standard *in vitro* technique. Supported by CTR grant #2130.

**ALEXANDRIA: THE FIRST ACADEMY OF SCIENCE.** James J. McGovern, Dept. of Health Administration, Va. Commonwealth Univ., Richmond, Va. 23298. The early development of scientific methods of inquiry at the Museum of Alexandria will be discussed. The role of the moving of Aristotle's library to Alexandria and the accomplishments of such students as Eratosthenes, Galen, Archimedes, Ptolemy, and Euclid will be analyzed. In particular, the Museum will be compared to the modern university in terms of its modes of faculty support and its evolutionary impact on Roman and Medieval institutions of learning. Philosophic inputs from Greek, Egyptian, and Jewish sources will be demonstrated to have important and long-lasting influences.

**N-PHENALKYL-2-SUBSTITUTED 2-AMINOTETRALIN DERIVATIVES:** 5-HT<sub>1A</sub> BINDING PROPERTIES. N. A. Naiman (1)\*, R. A. Lyon (2)\*, M. Titeler (2)\*, R. A. Glennon (1)\*. (1) Dept. of Med. Chem., School of Pharmacy; MCV/VCU, Richmond, Virginia 23298-0581 (2) Dept. of Pharmacology, Albany Medical College, Albany, New York. 8-Hydroxy-2-(di-n-propyl amino)tetralin (8-OH DPAT) was one of the first 5-HT<sub>1A</sub>-selective agonists, but little SAR have been formulated on the basis of receptor binding assays. We evaluated tetralin derivatives with structural changes at the 8-position and the amine. An oxygen-containing functionality at the 8-position is not essential for high affinity for 5-HT<sub>1A</sub> sites, but the presence of an oxygen does enhance affinity. Tertiary amines (bearing one small alkyl substituent) display equal affinity for 5-HT<sub>1A</sub> sites as the corresponding secondary amines. Phenalkyl substituents on the amine, in which the chain length was varied from 1-4 carbons between the amine and the phenyl ring, resulted in high affinity compounds. The phenpropyl analogue displayed the highest affinity at 5-HT<sub>1A</sub> sites ( $K_i=2$  nM). This affinity is comparable to that of 8-OH DPAT.

**DESIGN AND SYNTHESIS OF HIGH AFFINITY SEROTONIN 5-HT<sub>1A</sub> LIGANDS.** N. A. Naiman (1)\*, R. A. Lyon (2)\*, M. Titeler (2)\*, R. A. Glennon (1)\*. (1) Dept. of Med. Chem., School of Pharmacy; MCV/VCU, Richmond, Virginia 23298-0581 (2) Dept. of Pharmacology, Albany Medical College, Albany, New York. Arylpiperazines are generally considered to be 5-HT<sub>1B</sub>-selective agents, but several N<sub>4</sub>-alkylated piperazines display high affinity for 5-HT<sub>1A</sub> sites. Utilizing arylpiperazines [phenyl-, 2-methoxyphenyl-(2-MPP), and 1-naphthyl-(1-NP) piperazine] that display high affinity and/or selectivity for 5-HT<sub>1A</sub> sites, we investigated the SAR of the N<sub>4</sub>-substituent. Preliminary investigations identified piperazines bearing a 2-phthalimido moiety connected to the N<sub>4</sub>-position via a 4- or 5-carbon chain as high affinity 5-HT<sub>1A</sub> agents. The butylphthalimido derivatives of 1-NP and 2-MPP are among the highest affinity 5-HT<sub>1A</sub> agents known ( $K_i=1.0$  and  $0.6$  nM, respectively). The phthalimide moiety can be replaced with a benzamide without any loss of affinity, but the corresponding acetamide derivative had significantly lower affinity for these sites.

**MODULATION OF THE BREAST CENCER CELL LINE MCF-7 BY THYMOSIN ALPHA ONE.** Karen K. Oates, Marcia C. McGinty, Dept. of Biol., Geo. Mason Univ., Fairfax, Va. 22030. Control of the growth of human breast cancer has been characterized by the interplay of several growth factors and hormones in the body. One of the best models of growth factor synthesis by tumors has been the estrogen dependent human breast cancer cell line, MCF-7. We have identified immunoreactive thymosin alpha one (TAl) in the supernatants of the MCF-7 cells grown in TAl depleted media by radioimmunoassay. We hypothesize that if the MCF-7 cells utilize TAl in an autocrine manner, then we should be able to modulate their proliferative response to TAl. To test our theory, we used direct cell counts, anchorage dependent cloning (ADC) and tritiated thymidine incorporation assays to measure the proliferative response of the MCF-7 cells to TAl. The cells were treated with TAl in a dose response manner ( $1$  mg/ml to  $10^{-9}$  mg/ml); with and without estradiol ( $E_2$ ) at  $10^{-8}$  M.  $E_2$  is a known stimulator of the MCF-7 cells. The results indicated that TAl at ( $10^{-9}$ ) with  $E_2$  increases the number of ADC approximately 290% over cells with  $E_2$  alone. The incorporation of tritiated thymidine by cells treated with TAl at ( $10^{-7}$ ) with  $E_2$  increased 391% from cells treated with  $E_2$  alone. Indirect immunofluorescence antibody studies revealed cytoplasmic staining, indicating that TAl is present in the cytoplasm.



ANATOMIC PATHWAYS FACILITATING MIDDLE CEREBRAL ARTERY BYPASS. Noel O. Owers, Dept. of Anatomy, VA Commonwealth University, Richmond, VA 23298. The national cost of stroke is estimated to be 8 billion dollars a year at present. This figure will increase with the percentage increase of the older segment of the population, unless checked by new effective treatment protocols such as the one suggested here. Dissection of 6 cadaver heads revealed that there are 2.4 superficial temporal arteries (STA) and 3.6 middle meningeal arteries (MMA) per side. These have a diameter of 1 mm or greater that could be used to anastomose with peripheral branches of the middle cerebral artery (MMA) (Owers, Am. Surg. 53, 282-284, 1987). Since blockage of MCA usually occurs close to its origin, connecting its peripheral branches with branches of either STA or MMA would effectively restore circulation to the affected parts of the brain. Dissection of 39 cadaver heads, in a separate study, showed that of 39 heads, 38 (97.5%) showed MMA's 1mm or greater in diameter which would be available for anastomosis. These figures suggest that the availability of multiple donor arteries should facilitate cerebral revascularization in progressive ischemic stroke and that this should be done more often in selected patients.

#### NAPHTHYLOXYALKYLAMINES AS SEROTONIN AGONISTS AND ANTAGONISTS.

M. E. Pierson(1)\*, R. A. Lyon(2)\*, M. Titeler(2)\*, R. A. Glennon(1)\*. (1) Dept. of Med. Chem., School of Pharmacy; MCV/VCU, Richmond, Va. 23298-0581. (2) Dept. of Pharmacology, Albany Medical College, Albany, NY. Propranolol (PRO) is a  $\beta$ -adrenoceptor antagonist that binds with high affinity both to 5-HT<sub>1A</sub> and 5-HT<sub>1B</sub> binding sites ( $K_i$  90 nM and 50 nM, respectively). Whereas PRO is reported to be a 5-HT<sub>1A</sub> antagonist, we found that it is a 5-HT<sub>1B</sub> agonist in the drug discrimination paradigm. We were interested in designing and synthesizing selective 5-HT<sub>1A</sub> antagonists using PRO as a template. We identified and eliminated features of PRO that are important for  $\beta$ -adrenoceptor and 5-HT<sub>1B</sub> affinity, while retaining those features important for 5-HT<sub>1A</sub> affinity. These compounds were tested in radioligand binding studies, and in the drug discrimination paradigm using rats trained to discriminate either the 5-HT<sub>1A</sub> agonist 8-OH DPAT or the 5-HT<sub>1B</sub> agonist TFMPP from saline. Several of the analogs bind selectively at 5-HT<sub>1A</sub> sites, are inactive as 5-HT<sub>1B</sub> agonist, and are currently being evaluated as 5-HT<sub>1A</sub> antagonist.

STATISTICAL ANALYSIS OF ACQUISITION CURVES IN A RAT DRUG DISCRIMINATION PARADIGM. W. R. Prescott, J. A. Rosecrans\*, and B. R. Martin, Dept. of Pharmacol. & Toxicol. MCV/VCU, Richmond VA 23298. Male SD rats were trained to discriminate between the stimulus properties of i.p. delta-9-tetrahydrocannabinol (delta-9-THC, 3 mg/kg) and vehicle. The animals, maintained at approximately 80% of their free-feeding weight, were shaped to bar press for a food reward in a two-lever operant task using an increasing (1,3,5,7,10) fixed-ratio (FR) schedule of reinforcement. After the acquisition of discrimination, at a FR 10, doses of delta-9-THC ranging from 0.03-30 mg/kg were administered to test the dose responsiveness as well as the sensitivity of each animal to the drug cue. Additionally delta-8-THC, which is generally regarded as a less potent cannabinoid in this paradigm, was tested for generalization to the cue. Lever selection and responses / second (rr) were monitored as indications of the drug cue and general CNS depression respectively. The combined ED<sub>50</sub> was approximately 0.1 mg/kg. However, individual animals varied greatly both in their ability to detect the drug, with some demonstrating an ED<sub>50</sub> at or below 0.03 mg/kg, and in the degree of response rate depression. Similar variability was seen in the results from the generalization testing with delta-8-THC. The test and training data are examined in an attempt to correlate these variations with various parameters recorded for each rat during the course of the experiment.



EFFECT OF VITAMIN E ON VITAMIN C INDUCED LYMPHOCYTOPENIA. John H. Richardson and Leslie Davidson, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529-0266. Forty mice were removed from the control room to a room for stressing. Before stressing a lymphocyte count was taken from each animal, and a mean control lymphocyte count of 48.0 per 100 white blood cell count was calculated for all 40 animals. Stressing of the animals consisted of crowding two groups of 20 animals in two cages each with the dimensions that was used for two control animals. Twenty animals received daily intraperitoneal injections of one mg of sodium ascorbate (vitamin C) for 16 days. Another group of 20 received the ascorbate plus daily 50 mg per kg of body weight of oral alpha trocopheral acetate (vitamin E) for 16 days. A mean experimental lymphocyte count was recorded on alternate days for the two groups of experimental animals. Vitamin C plus E resulted in less severe lymphocytopenia than the C group because of the lymphoproliferative effect of vitamin E.

QSAR OF 4-SUBSTITUTED 2,5-DIMETHOXYPHENYLISOPROPYLAMINES AND ITS APPLICATION TO THE DESIGN OF NEW HIGH AFFINITY 5-HT<sub>2</sub> LIGANDS. M.R. Seggel\*, M. Youssif\*, R.A. Lyon\* +, M. Titeler\* +, R.A. Glennon\* Dept. of Med. Chem. MCV/VCU, Richmond, VA 23298-0581. + Dept. of Pharmacology, Albany Med. Col. Albany, NY. We previously reported (This journal, Summer 1986, 37(2), Abstracts of Papers) that the lipophilic character of the 4-substituent of 4-substituted 2,5-dimethoxyphenylisopropylamines (4-X-2,5-DMA's) was the principle factor influencing the affinity of these compounds for [3H]Ketan-serin-labeled 5-HT<sub>2</sub> sites. Based on these earlier QSAR studies, nine additional 4-X-2,5-DMA's were designed, synthesized and evaluated. As predicted, those compounds with lipophilic 4-substituents displayed high affinity for the 5-HT<sub>2</sub> receptor. Hansch analysis confirmed the importance of the lipophilicity of the 4-substituent:  $\log (1/K_i) = 5.93 + 0.73\pi$ ,  $r = .85$ ,  $s = .61$ ,  $n = 25$ . The shape of the 4-substituent may also be important for affinity, whereas its electronic properties may be important for agonist activity. Preliminary results suggest that some 4-X-2,5-DMA's have antagonist activity, and represent a novel class of 5-HT<sub>2</sub> antagonists.

IDENTIFICATION OF DIASTEREOMERS OF PHENOBARBITAL N-GLUCOSIDES IN HUMAN AND MOUSE URINE. Phyllis J. Soine, Dept. of Chem., Randolph-Macon Col., Ashland, Va. 23005 and T.E. England and W.H. Soine, Dept. Med. Chem., Va. Commonwealth Univ., Richmond, Va. 23298. Phenobarbital (PB) has been shown to undergo N-glucosylation in humans. When PB is coupled to glucose, two diastereomers, PBGA and PBGB, are formed. Upon analysis of human urine following administration of PB, a pronounced product enantioselectivity is observed. Approximately 10 % is excreted as PBGA and 1 % as PBGB. The rate of urinary excretion of PBGA appears to parallel the urinary excretion of PB. To facilitate the studies of formation and excretion of N-glucosylation of PB a species screen was undertaken. Only mice were observed to excrete PB N-glucosides in their urine, however, they excreted primarily PBGB and very small quantities of PBGA. Although different product enantioselectivity is observed for mice, they may be useful as an animal model to study the N-glucosylation pathway in greater detail. (Supported by NIH grant GM34507).

ATRIAL DIPEPTIDYL CARBOXYHYDROLASE CAN ACT AS A TRIPEPTIDYL CARBOXYHYDROLASE. Dulce Soler-Ferran & Robert B Harris, Dept. of Biochemistry, Va. Commonwealth Univ., Richmond, Va. 23298. Intramolecularly quenched fluorogenic substrates of the general structure 2ABz-G-X-F(4-nitro)-R were synthesized for use in a continuous and highly sensitive assay for atrial dipeptidyl carboxyhydrolase. Based on the ratio of  $V_{max}/K_m$  the best substrate is  $X=S>A=K>N>>>T=D$ . Atrial dipeptidyl carboxyhydrolase is associated with atrial granules and converts one atrial natriuretic peptide, atriopeptin II to another atrial peptide, atriopeptin I by removal of the c-terminal dipeptide F-R. Another atrial natriuretic peptide, atriopeptin III, is directly converted to atriopeptin I by a tripeptidyl cleavage catalyzed by the same enzyme that releases the c-terminal tripeptide F-R-Y which is subsequently degraded by the enzyme to F and R-Y. However, the predominant cleavage when using this substrate is still the removal of the c-terminal dipeptide. In contrast, when an amidated atriopeptin III analogue is used as a substrate, the enzyme acts entirely as a tripeptidyl carboxyhydrolase. The features of these substrates that confer the shift in cleaving points are being studied. Atrial-di-(tri)-peptidyl carboxyhydrolase is readily inhibited by metal chelating agents; EDTA>EGTA and o-phenanthroline. Activity is restored by the addition of divalent metal ions such as cobalt, zinc and manganese.

EXAMINATION OF ANXIOGENESIS AND ANXIOLYSIS PRODUCED BY REPEATED ADMINISTRATION AND WITHDRAWAL FROM NICOTINE AND ETHANOL. Sherrill L. Todd\*, E.S. Onaivi\*, & B.R. Martin, Pharmacol. & Toxicol., MCV/VCU, Richmond, VA 23298. The mechanism by which ethanol or nicotine produces dependency and withdrawal symptoms is poorly understood. Therefore, anxiety and locomotor activity were investigated during repeated ethanol and nicotine treatment and following cessation of these treatments. Four groups of ICR male mice ( $N=6/\text{group}$ ) received either no treatment, a gavage of 2.8 g/kg ethanol, 1 mg/kg nicotine (s.c.) twice daily, or the combined treatments for 14 days before withdrawal. The animals were tested on days 2, 7, 10 and 14 during treatment and at 24 and 48 hr, and 5 days after withdrawal for locomotor activity and then anxiolysis/anxiogenesis using the elevated plus-maze. Locomotor activity was unchanged during any of the treatments. Activity was significantly depressed in the combination group up to 5 days after withdrawal. The individual and combination treatments showed a significant increase in anxiolysis during the treatments. In addition, the anxiolysis in the combination group was greater than that in either the nicotine or ethanol groups alone. After withdrawal, the ethanol and the nicotine groups were not significantly different from the controls in the anxiety test. The combination group showed increased anxiogenesis at 24 and 48 hr which disappeared by 5 days. It is therefore concluded that the combined use of ethanol and nicotine will produce exaggerated anxiolysis during treatment, and upon withdrawal will produce anxiogenesis which may be a basis for continued intake. (Supported by VA Commonwealth Ctr on Drug Abuse.)

IDENTIFICATION AND CHARACTERIZATION OF THE DECOMPOSITION PRODUCTS OF PHENOBARBITAL N-GLUCOSIDES. F.B. Vest\* W.H. Soine, R.B. Westkaemper, Dept. Med. Chem., Va. Commonwealth Univ., Richmond, Va. 23298, & P.J. Soine, Randolph-Macon Col. Ashland, Va. 23005. Phenobarbital N-glucosides (PBGA and PBGB) are major urinary excretion products of phenobarbital (PB) in humans. It was observed that PBGA and PBGB decompose under conditions in which no decomposition of PB occurs. The rate-pH profile (pH 6-12) was determined and indicated hydroxide-ion-catalyzed degradation of unionized and ionized PBGA and PBGB. The observed rate constants of decomposition at pH 7.4 (37°C) were  $4.13 \times 10^{-5} \text{ s}^{-1}$  and  $3.47 \times 10^{-5} \text{ s}^{-1}$  for PBGA and PBGB, respectively. This is 580 times that of PB under comparable conditions. The two major decomposition products were characterized using thermospray LC/MS, IR and  $^1\text{H-NMR}$ , and identified as N-( $\beta$ -D-glucopyranosyl)phenylethylmalonamide and N3-( $\beta$ -D-glucopyranosyl)phenylethylacetylurea. The rapid breakdown of the N-glucosides suggests their decomposition could be occurring in the plasma and urine. (Supported by NIH grant GM 34507.)



MODULATION OF INTRACELLULAR IONIZED CALCIUM BY MORPHINE, SALMON CALCITONIN (sCT) AND CGRP ALONE, AND IN COMBINATION. Sandra P. Welch and William L. Dewey, Dept. of Pharmacology/Toxicology, Medical College of Virginia, Richmond, VA 23298.

Morphine (MOR), sCT, and CGRP have previously been shown to produce or modulate antinociception by altering calcium fluxes in the brain. No previous work has shown the effects of these drugs on free intracellular calcium  $[Ca^{++}]_i$ . Our results using mouse whole-brain synaptosomes indicate that both sCT and CGRP produce rapid (1sec) increases in  $[Ca^{++}]_i$  followed by attenuation of depolarization-induced increases in  $[Ca^{++}]_i$ . Upon 1 hr incubation of synaptosomes with sCT or CGRP, the rise in  $[Ca^{++}]_i$  upon depolarization is also attenuated. MOR blocks the rise in stimulated  $[Ca^{++}]_i$  due to depolarization, an effect blocked by naloxone and modulated by CGRP. Verapamil-induced blockade of the rise in  $[Ca^{++}]_i$  upon depolarization is enhanced in the presence of CGRP. These data indicate that modulation of  $[Ca^{++}]_i$  as a result of  $Ca^{++}$  flux modulation is important in the production of an antinociceptive response.

AN MNDO STUDY OF CARBONYL ADDITION REACTIONS: MODELS OF ENZYMATIC ACYL TRANSFER. R. B. Westkaemper, Dept. Med. Chem., Va. Commonwealth Univ., Richmond, Va. 23298. Aldehydes and ketones with electron withdrawing substituents exist as equilibrium mixtures of carbonyl and gem diol in aqueous solution. The addition of water to a carbonyl is analogous to the nucleophilic addition step of enzymatic acyl transfer reactions. We have evaluated the correlation between properties of the reactants and products calculated using the MNDO semiempirical molecular orbital method and the equilibrium constants ( $K_h$ ) for diol formation. Parameters evaluated include optimized C=O bond lengths, carbon and oxygen point charges of reactants and products, energy of LUMO and HOMO, and difference between calculated heats of formation of reactants and product.  $K_h$  correlates well with C=O bond length but very poorly with calculated heat of reaction. Statistical analysis of the results suggests that  $K_h$  is best correlated with a function of charge separation and C=O bond length. Calculated parameters perform as well as experimentally derived (Taft  $E_s$ ,  $\sigma^*$ ) substituent constants in predicting the extent of hydration. (Supported by VCU Grant-In-Aid)

GLYCOSYLTRANSFERASES IN CRYPTOCOCCUS NEOFORMANS. Catherine W. White, Dept. of Biochem., Med. Col. of Va., Richmond, VA 23298 and Eric S. Jacobson, Dept. of Medicine, Med. Col. of Va., Richmond, VA 23298. The glucuronylxylosylmannan of Cryptococcus neoformans is synthesized from nucleosidediphosphate sugars by glycosyltransferases residing in the membrane fraction. Acceptors for the *in vitro* reactions are an acetylated mannan from Dictyophora indusiata for glucuronic acid, dextrosylated polysaccharide from Tremella mesenterica for xylose, and methylmannopyranosylmannopyranoside for mannose. The glucuronyltransferase is most active at a low pH; the xylosyltransferase prefers a low temperature. The mannosyltransferase is the only one with a stringent requirement for a cation. All three show an increase in activity with increasing enzyme, substrate or acceptor. (Supported by Research Service, McGuire V. A. Med. Ctr., Richmond, VA 23249.)



THE INTERACTION OF COMPLEMENT PROTEINS WITH PATHOGENIC STRAINS OF *NAEGLERIA FOWLERI*. L. Y. Whiteman and F. Marciano-Cabral, Dept. of Micro. and Immuno., VA Comm. Univ., Richmond, Va. 23298. The susceptibility of four species of *Naegleria* amoebae to complement-mediated lysis was determined. The amoebicidal activity of normal human serum (NHS) and normal guinea pig serum (NGPS) for *Naegleria* spp. was measured by the release of  $^3\text{H}$ -uridine from labeled amoebae. Susceptibility to lysis correlated with pathogenic potential. The highly pathogenic mouse-passaged *N. fowleri* was less susceptible to the lytic effects of NHS and NGPS than the weakly pathogenic, axenically grown *N. fowleri* or *N. australiensis* and the nonpathogenic *N. gruberi* and *N. lovaniensis*. The presence of specific antibody enhanced the lytic activity of NGPS for *N. gruberi* and axenically grown *N. fowleri*, but not for the mouse-passaged *N. fowleri*. Pathogenic and nonpathogenic *Naegleria* spp. depleted complement as assessed by the decrease in total hemolytic activity. Immunoelectrophoresis of NHS pre-incubated with *Naegleria* revealed the production of C3a and C3b activation cleavage fragments which corresponded with cell lysis. Treatment of the mouse-passaged *N. fowleri* amoebae with trypsin or papain increased their susceptibility to lysis; however, treatment of the highly pathogenic amoebae with sialidase did not alter their susceptibility to lysis.

#### PROCESSING OF PRO-ATRIAL NATRIURETIC FACTOR BY ATRIAL GRANULE-ASSOCIATED SERINE PROTEINASE Donna M. Wypij\* and Robert B. Harris, Dept. of Biochem., Va. Commonwealth Univ., Richmond, Va. 23298.

A serine proteinase (M<sub>r</sub> 70,000) capable of hydrolyzing synthetic substrates which mimic a processing site in pro-atrial natriuretic peptide (pro-ANF) has been isolated from bovine atrial granule preparations. Only the Arg-Ser bond in the substrates Gly-Pro-Arg-Ser-Leu-Arg, Benzoyl(Bz)-Gly-Pro-Arg-Ser-Leu-Arg, and Bz-Gly-Pro-Arg-Ser-Leu-Arg-Arg-2-Naphthylamide(NA), and the Arg-2NA bond in Bz-Gly-Pro-Arg-2NA are hydrolyzed by this proteinase. A 31-residue synthetic peptide (Gly96-Tyr126, corresponding to the C-terminal sequence in pro-ANF) is cleaved by the atrial enzyme at the Arg98-Ser99 bond yielding Ser99-Tyr126 (cardionatriin I). The doublet of basic amino acids in pro-ANF is not the primary processing site; Ser103-Tyr126 atrial peptide is formed only after prolonged incubation or at high enzyme concentrations. Upon homogenization of atrial granules, only detergents cause enzyme release, suggesting an inner membrane association. Additional enzyme purification results will be discussed, as well as native-PAGE of the enzyme with subsequent fluorescent visualization of enzyme band activity. Our results suggest that this processing enzyme of pro-ANF is present within the atrial granules and in response to a proper stimulus, pro-ANF is processed to active peptides.

#### PROTEOGLYCANS SYNTHESIZED IN AORTIC ORGAN CULTURE. Marie J. Yates, Claire Fornsel, Morry Brown, and H. Alan Rowe, Department of Chemistry, Norfolk State University, Norfolk, Virginia 23504

The role of proteoglycans (PG) in normal and pathogenic artery wall function is not at all well established. Basic questions still remain concerning the structure and synthesis of these carbohydrate-protein macromolecules in various tissues. The present study examines the PG isolated from aortic tissue in organ culture. Fresh bovine aortic arch was incubated with  $\text{Na}[^{35}\text{S}]\text{O}_4$  *in vitro*. The PG were extracted with 4.0 M guanidine HCl in 0.05 M Na Acetate pH 5.8 in the presence of protease inhibitors. The extract was concentrated and further purified via Sepharose CL-4B chromatography. The  $^{35}\text{S}$ -dpm was used as an indication of the newly-synthesized PG while chemical assay of hexuronate measured the mass of PG already present in the tissue. The % yield and fold-purification were calculated for each purification step. A differential purification of the newly-synthesized versus the "status quo" proteoglycans was indicated. (supported by NIHRR08033)

CHARACTERIZATION OF CYTOLYTIC PROTEINS FROM NAEGLERIA FOWLERI AMOEBAE. Kathy L. Zogghy & Francine Marciano-Cabral, Dept. of Micro and Immuno., VA Comm. Univ., Richmond, VA. 23298. We have initiated studies to characterize differences between weakly pathogenic (LEE) and highly pathogenic (LEE mouse-passaged) strains of N. fowleri. Initial studies have entailed subcellular fractionation of the two strains of amoebae to allow for purification and characterization of Naegleria surface membrane molecules. Whole cell homogenates of N. fowleri amoebae were prepared by glass bead disruption. Self-generating Percoll gradients then were employed for the separation of the homogenate into fractions containing subcellular organelles. Fractions obtained from the Percoll gradients were prepared for transmission electron microscopy using thin-sectioned preparations to establish their subcellular composition. Enzyme marker assays were employed to confirm the membrane, lysosomal and mitochondrial fractions. Fractions from Percoll gradients containing 5'-nucleotidase and acid phosphatase activity and identified by EM as membrane fractions were highly cytotoxic for B103 nerve cells. Size exclusion HPLC of the various fractions indicate low molecular weight proteins (<1,350 daltons) as well as a higher molecular weight peak of approximately 50,000 daltons.

## Microbiology

COMPLEMENTATION ANALYSIS OF INSERTION MUTANTS IN THE rfa LOCUS OF THE E. coli CHROMOSOME. Elizabeth A. Austin and Carl A. Schnaitman, Dept. of Microbiol., Univ. of Va., Charlottesville, Va. 22908. The rfa locus, located at 81' on the E. coli chromosome, encodes the glycosyl transferases necessary for synthesis of the core polysaccharide of lipopolysaccharide (LPS). Mutations in the core region proximal to the lipid A moiety are known as "deep rough" and result in profound alterations of the outer membrane such as decreases in the levels of the major outer membrane proteins, increased sensitivity to hydrophobic compounds, and changes in patterns of phage sensitivity. Insertion mutants with these characteristics were isolated after mutagenesis with mini-Tn10 followed by selection for tetracycline and phage U3 resistance. These mutants mapped to a 2.2 kilobase region within the rfa locus. DNA fragments from a Clarke-Carbon plasmid, pLC10-7, were subcloned into  $\lambda$ gt4.0 and lysogenized in cells containing the insertions. The degree of complementation was assessed by examining the outer membrane protein profile, the LPS produced, the phage U3 sensitivity pattern, and sensitivity to hydrophobic compounds. Increasing the length of the cloned DNA fragment results in a greater degree of complementation. These results indicate that the rfa locus is organized as an operon.

ANAEROBIC DEGRADATION OF PENTACHLOROPHENOL BY GROUNDWATER ENRICHMENT CULTURES OF NITRATE AND SULFATE RESPIRING BACTERIA. Steven A. Baranow & Robert E. Benoit, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. The goal of this research was to evaluate the potential of groundwater microorganisms to degrade pentachlorophenol (PCP) in anaerobic enrichment culture. Subsurface soil samples from a Philadelphia refinery site and a pristine Virginia site were each inoculated into a complex nitrate reducer enrichment medium containing 5 ppm PCP. After subsequent transfers into media with increased PCP concentration, degradation rates were measured in media containing 40 ppm PCP by HPLC and Cl<sup>-</sup> analysis. The Philadelphia culture exhibited significant degradation after 32 days incubation while the Virginia culture did not show degradation after 16 days incubation. Philadelphia soil was also inoculated into a complex sulfate reducer enrichment medium. After 37 days incubation, >70% PCP degradation was observed. Intermediates consisted of 2,4,5- & 2,4,6-trichlorophenol. We have not been able to isolate a pure culture of an anaerobic PCP degrading bacterium from groundwater. This is the first report of PCP degradation by groundwater microorganisms in anaerobic enrichment media. (Supported by grants from the Va. Academy of Science and Sigma Xi.)



CONSTRUCTION AND EXPRESSION OF CHOLERA TOXIN B SUBUNIT FUSION PROTEINS. Mark T. Dertzbaugh\* & Francis L. Macrina, Dept. of Microbiol. & Immunol., VA Commonwealth Univ., Richmond, VA 23298. A set of plasmid cloning vectors are described for creating translational fusions to the B subunit gene of cholera toxin (ctxB) in E. coli. These vectors permit insertion of transcriptionally and translationally competent gene sequences upstream of ctxB. A portion of the glucosyltransferase B gene (gtfB) from the cariogenic bacterium Streptococcus mutans GS-5 (serotype c), encoding the amino terminal one-third of the protein, was inserted into each vector. E. coli lysates containing the constructs were partially purified by passage over a GM<sub>1</sub> ganglioside affinity column. Western blotting analysis of the column retentate from one of the lysates revealed the presence of a novel 58 kd protein which cross-reacted with antisera to glucosyltransferase B and to the B subunit of cholera toxin (CtxB). This chimeric protein will be used to assess the efficacy of CtxB conjugates as oral vaccines.

ISOLATION AND IDENTIFICATION OF SIDEROPHORES FROM FUNGI. Alan H. Faustino and Judy H. Niehaus, Dept. of Biol., Radford Univ., Radford, VA 24142. Because most of the Fe(III) in nature is insoluble and biologically inaccessible, many bacteria and some fungi produce small iron-binding compounds called siderophores to solubilize iron and return it to the cell. A total of 32 strains of fungi, including some fresh field isolates, were tested for siderophore production in low-iron Grimm-Allen or Hagem's medium with and without malt extract. Fifteen of the 32 strains produced siderophores. Siderophores were tentatively identified by visible absorption spectra and thin-layer chromatography in CHCl<sub>3</sub>:methanol:H<sub>2</sub>O (35:12:2) and butanol:acetic acid:H<sub>2</sub>O (4:1:5). Data were compared with published results or data from control strains. Suillus variegatus produced three siderophores with R<sub>f</sub> values of 0.19, 0.28, and 0.61 in the first solvent system and 0.49, 0.78, and 0.79 in the second. Lactarius indigo and Boletus edulis produced a siderophore with an absorption spectrum similar to the Ustilago sphaerogena control, and the siderophore was tentatively identified as ferrichrome. (Supported by a grant from the Virginia Academy of Science.)

DOPED OLIGONUCLEOTIDE-DIRECTED MUTAGENESIS OF THE ESCHERICHIA COLI btuB GENE. Augusta Gudmundsdottir, Robert J. Kadner, and Clive Bradbeer, Departments of Microbiology and Biochemistry, University of Virginia School of Medicine, Charlottesville, VA 22908

Transport of vitamin B<sub>12</sub> across the Escherichia coli outer membrane involves high affinity binding of B<sub>12</sub> to the BtuB protein followed by its energy dependent transport across the outer membrane which requires the TonB interaction. All proteins who require the TonB function for activity share a homologous pentapeptide at their amino termini called the "TonB box". Data from our laboratory indicate that the pentapeptide is involved in TonB interaction. The btuB451 mutation, converting Leu<sub>8</sub> to Pro results in loss of energy dependent B<sub>12</sub> uptake and mutations in the TonB protein complementing the btuB451 mutation have been isolated. To further analyse the importance of the pentapeptide we have mutagenized the corresponding region of the btuB gene, using "doped" oligonucleotide mutagenesis. Thus far we have obtained 17 different amino acid changes in the pentapeptide region, some of which strongly affect vitamin B<sub>12</sub> transport, whereas other changes have no apparent effect.



NOVEL CONJUGATIVE TRANSPOSON OF BACTEROIDES FRAGILIS

Madelon Halula<sup>\*</sup>, Michael McVoy<sup>\*</sup>, and Francis L. Macrina  
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Resistance to clindamycin in Bacteroides fragilis may be plasmid or non-plasmid associated. While several plasmid encoded clindamycin resistance (ermF) determinants have been well characterized, little is known about the more common non-plasmid transferable clindamycin resistance elements. We sought to characterize the non-plasmid erm-like element from B. fragilis V503. A DNA fragment carrying part of ermF from Tn4351 was used to screen a genomic cosmid library derived from the Cc<sup>R</sup> transconjugate V622. Cosmid pVA1531, detected by ermF hybridization, contained an insert of 27 kb. The erm-like determinant was localized to a 6 kb EcoRI fragment. DNA corresponding to the ends of this cloned segment were used as probes to detect homologous DNA in the donor, recipient, and transconjugates. Results showed that pVA1531 contained no recipient DNA sequences. The erm-like sequences were shown to reside on the chromosome by demonstrating that DNA homologous to ermF corresponded to the chromosomal component after OFAGE. We conclude the transferable genetic element (Tn5030) encoding clindamycin resistance in B. fragilis V503 and B. uniformis V622 is a conjugative transposon larger than 27 kb.

GENETIC ANALYSIS OF A BROAD HOST RANGE CONJUGAL PLASMID. E. Regis Krah III<sup>\*</sup>

and Francis L. Macrina. Dept. of Micro. and Immuno., Va. Commonwealth Univ., Richmond, VA 23298. pIP501 (30.2 kb) is a streptococcal broad host range conjugal plasmid which carries genes for chloramphenicol and erythromycin resistance. Our goal has been to define the genes necessary for conjugation. A conjugal proficient derivative (pVA1702, 25.2 kb) has been constructed in which 8 kb of the parental plasmid has been deleted removing both resistance genes and inserting in their place a kanamycin gene from another streptococcal plasmid. pVA1702 transfers at a slightly higher frequency than pIP501 in syneigeic S.faecalis filter matings. Using pVA1702 as a target for transposon mutagenesis with Tn917 and Tn917lac, we have found three separate regions of the plasmid spanning a region of 14 kb in which insertions abolish transfer. Recent work indicates pVA1702 has a restricted host range, failing to transfer at a detectable frequency to S.sanguis in S.faecalis (donor)/S.sanguis (recipient) matings. Surprisingly, when transformed into S.sanguis, pVA1702 readily conjugates into S.faecalis.

'GENES' AMPLIFIED. Muriel Lederman, Dept. of Biol., Va. Polytechnic Inst., Blacksburg, VA 24061. Kitcher has suggested that preservation of reference of 'gene' between transmission genetics and molecular biology will allow one to "transcend" the debate about reduction between these disciplines. Actually, biologists employ different concepts of the gene at the same time and address different concepts of the gene simultaneously in one experiment. This fact has the consequence of eliminating reduction as a necessary strategy for explaining the relationship between genetics and molecular biology. Restriction fragment length polymorphisms address 'gene' as a determinant of a phenotype (in the tradition of transmission genetics) and 'gene' as a structural concept in which phenotype is identical to genotype (a molecular biological concept). Since both these concepts are used in the same experiment, it suggests that the continuum between these disciplines is circular instead of the linear relationship implicit in reduction, if concepts of gene are discrete. Two strategies demonstrate the discrete nature of gene concepts. Consequently, reduction is not necessary to relate these disciplines since any concepts of 'gene' may be juxtaposed in a non-predictable way. The conjunction of concepts from genetics/molecular biology and cell/developmental biology suggests that reduction will not be needed in the future to relate these disciplines.

PRELIMINARY ANALYSIS OF POLY-BETA-HYDROXYBUTYRATE PATHWAY PROTEINS. Leslie E. Metker and Douglas Dennis, Dept. of Biol., James Madison University, Harrisonburg, VA 22807. The poly-beta-hydroxybutyrate biosynthetic pathway has previously been cloned into a cosmid vector and then subcloned on a 14 kb fragment into a small multicopy plasmid vector. In this project, we further subcloned the pathway on a 5.2 kb fragment into the plasmid pUC19. In order to characterize the proteins encoded by the PHB biosynthetic pathway, the 5.2 kb fragment was cloned into vectors developed for specific *in vivo* expression of plasmid-borne genes. Experimental data suggests that there are three PHB-specific proteins, as judged by the autoradiography of SDS-polyacrylamide gels. These proteins have approximate molecular weights of 47.3, 28.1, and 10.6 kilodaltons. Based on the findings of other research groups, the 47 kilodalton protein may be beta ketothiolase, the first enzyme of the biosynthetic pathway.

INSERTIONAL INACTIVATION OF STREPTOCOCCUS MUTANS V403 FRUCTOSYL TRANSFERASE GENE Valerie A. Schroeder\* & Francis L. Macrina, Dept. of Microbiol. & Immunol., VA Commonwealth Univ., Richmond, VA 23298. The Streptococcus mutans fructosyl transferase (*ftf*) may play a role in the formation of dental caries by synthesizing a fructan polymer that serves as an extracellular storage polysaccharide. The *ftf* gene of S. mutans GS5 has been cloned and sequenced. We used these cloned genes in Southern hybridization experiments to detect a homologous *ftf* gene in S. mutans V403. Four EcoRI fragments were identified in V403 which corresponded in size to an EcoRI digest of the GS5 *ftf* gene. Hybridization to V403 sequences suggested that the cloned GS5 *ftf* gene could be used for *in vivo* modification of V403 *ftf* gene. Nucleotide sequence data of the *ftf* gene revealed a unique XhoI restriction site in the middle of the gene. This site was used to make a defective copy of the gene by insertion of DNA which carried an erythromycin resistance determinant. The resultant recombinant plasmid was transformed into S. mutans V403 where it replaced the wild-type *ftf* sequences with the defective *ftf* gene construction. Southern hybridization analysis was used to verify the insertion of the erythromycin gene. These *ftf* deficient mutants will be used to determine the role of the fructosyl transferase in colonization and the formation of dental caries.

PRODUCTION OF A COPPER BINDING COMPOUND BY THE MARINE BACTERIUM, VIBRIO ALGINOLYTICUS. V.H. Sears and A.S. Gordon, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508. Vibrio alginolyticus responds to toxic levels of copper with a growth lag proportional to the concentration of added copper. SDS-polyacrylamide gel electrophoresis reveals copper-induced proteins of 21,000-25,500 D which are released into the medium.

Copper challenged supernatants fractionated by gel permeation chromatography have a small increase in absorbance at 254 nm in fractions corresponding to the same molecular weight as the induced SDS-PAGE bands. Copper binding activity measured with a  $\text{Cu}^{2+}$  specific electrode is present in these fractions in copper challenged cultures but not in control fractions.

These data indicate that V. alginolyticus synthesizes a protein(s) in response to copper challenge. These proteins, when released into the medium, may serve to detoxify copper through the formation of dissolved copper-protein complexes.

ISOLATION AND CHARACTERIZATION OF AN EXOTOXIN PRODUCED BY A MARINE BACTERIUM. S. Sheffield and A. S. Gordon, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508. Production of an antimicrobial compound from a marine bacterium isolated from the lower Chesapeake Bay was examined as a function of temperature, pH, salinity and time. The unidentified organism, designated #326, is a Gram negative, pigmented rod which produced a compound that was toxic to S. aureus and Ehrlich ascites tumor cells *in vitro*. Production of the toxin began within 24 hours in cultures of #326 with an optimal activity occurring on day seven. The production of the compound was maximal under conditions approximating those of the habitat from which the organism was isolated. Optimum conditions for production were after seven days in seawater medium with a salinity of 3% at 25° C and pH 7.5.



CLONING OF THE GENES ENCODING A PORTION OF THE PROTON-TRANSLOCATING ATPASE OF STREPTOCOCCUS MUTANS. Scott V.W. Sutton<sup>\*</sup> and Francis L. Macrina, Dept. of Microbiology and Immunology, Va. Commonwealth Univ., Richmond, VA 23298. Streptococcus mutans is an extremely aciduric organism, able to survive in the acid environment characteristic of a carious lesion. This acidurance is due, in large part, to the cells ability to translocate protons from the cytoplasm of the cell to the exterior through the proton-translocating ATPase of the cell membrane. The biochemical characteristics of the proton-translocating ATPases from S. mutans, S. sanguis and Lactobacillus casei have been examined and are consistent with the observed acidurance of the particular oral microorganism. We have isolated chromosomal DNA from a genomic library of S. mutans V403 in the lambdaphage EMBL3 that contains sequences complementary to genes encoding the F<sub>1</sub> moiety of Bacillus megaterium. This DNA has been subcloned on a 4.1 Kbp insert in pUC18 and as part of a 8.6 Kbp insert on pACYC184. Chromosome walking experiments have been carried out to isolate sequences of DNA in the chromosome that flank the identified region. Characterization of the cloned DNA is underway. This DNA, with its flanking sequences, is being used to construct mutants of the H<sup>+</sup>-ATPase in S. mutans V403.

## Psychology

INFORMATION TRANSFER CHARACTERISTICS OF EMERGENCY VEHICLE WARNING LIGHTS: EVALUATING SEQUENCE STEREOTYPES. James D. Blacksher, Dept. of Psyc., Old Dominion Univ., Norfolk, Va. 23529-0267. Emergency vehicle warning lights do not reliably convey direction and rate of travel information to observers under all conditions. Utilization of defined flash sequences in multi-light systems may provide important cognitive cues to motion in augmentation of perceptual determinations of vehicle movement. Sequences chosen should utilize existing population stereotypes which associate specific flash patterns with particular types of movement. Each of four flash patterns (center to ends, ends to center, left to right, and right to left) were associated with one of four conditions (approaching, moving away, parked to left, and parked to right). Results indicate that balanced (center to ends and ends to center) sequences are associated with moving vehicles and directional (end-to-end) sequences are associated with parked vehicles. Alternatives within the balanced and the end-to-end sequences yielded no significant preference, but suggest the possibility of competing stereotypes. The display of separate flash sequences in moving and stopped emergency vehicles appears to warrant consideration, whereas direction of movement encoding would require driver familiarization.

RELATIONS BETWEEN SELF-DISCLOSURE AND MENTAL HEALTH: RESULTS FROM A NATIONAL LESBIAN HEALTH CARE SURVEY. Chris Bjornsen,<sup>\*</sup> Survey Research Lab., Va. Commonwealth Univ., Richmond, Va. 23284, J. Bradford,<sup>\*</sup> Survey Research Lab., Va. Commonwealth Univ., Richmond, Va., 23284, & C. Ryan,<sup>\*</sup> George Washington Univ., Washington, D.C. 20007. Data from the 1985 National Lesbian Health Care Survey (N=1,917) is employed to investigate the relations between self-disclosure, mental health, and use of counseling services across several age groups. Self-disclosure represents the degree to which respondents were "out" to gay friends, straight friends, family members, and co-workers. The highest degree of self-disclosure to all four groups was reported by women 25 to 34 years of age. Employing power polynomial regression analyses, we find that a significant cubic trend best describes the relation between age and self-disclosure to family members ( $p<.005$ ), and significant quadratic trends best describe the relations between age and self-disclosure to straight friends ( $p<.000$ ) and outness to co-workers ( $p<.05$ ). Outness to straight friends is the best predictor of mental health and counseling variables included in the survey questionnaire. We argue that the ability to disclose one's lesbian identity to heterosexual friends is a consistent and practical issue to consider when studying or working with the lesbian population.



**BEHAVIORAL INTENTIONS AND ALCOHOL CONSUMPTION: A FIELD STUDY.** Melanie J. Bonner\*, Michael J. Kalsher\*, & Lisa C. Burnette\*, Va. Polytechnic Inst. & State Univ. The alcoholic beverages available to students of legal-drinking age at a weekend fraternity party (i.e., mixed drinks & beer) were served either by bartenders or by themselves. The dependent measures of interest were 1) drinking rate, 2) exit BAC, and 3) predictability of students specific pre-party intentions toward drinking (i.e., number of cups consumed) and level of impairment (i.e., exit BAC). Type of drink delivery (i.e., bartender vs. self-serve) impacted parties' drinking rates. Specifically, beer drinkers in the self-serve condition drank at the greatest rates, whereas those consuming mixed drinks in the self-serve condition drank at the lowest rates. Mixed drink and beer drinkers in the bartender condition drank at a similar rate throughout the party. However, there were no significant differences in mean exit BAC between beverage delivery conditions or between beverage type. Males drank at a greater rate across all conditions than did females (3.0 vs. 2.3 cups per hour) and also had higher average exit BACs (.112 vs. .078). Specific intentions toward drinking and impairment were significant predictors of actual number of cups consumed ( $R^2=.21$ ) and level of impairment attained ( $R^2=.59$ ).

**THE EFFECTS OF AUDITORY STIMULI ON SKIN TEMPERATURE DURING BIOFEEDBACK.**

Eva G. Clarke and P. J. Mikulka, Old Dominion Univ., Norfolk, VA, 23508. This study investigated the effects of presenting positive, negative and neutral affective auditory stimuli, during biofeedback, while subjects were attempting to increase their skin temperature. Each subject received three consecutive days of biofeedback training for hand warming. On day one, no stimuli were presented. During training on the second and third days, three stimuli were presented. The presentations of the stimuli were counterbalanced. Upon completion, the subjects were dichotomized into two groups based on whether they were successful (able to increase their skin temperature on two of the three days) or unsuccessful. A Groups (1-2) x Trials (1-16) x Days (1-3) ANOVA revealed a significant interaction between Groups and Trials ( $p < .0001$ ). A Groups x Stimuli (5 stimuli plus baseline) ANOVA revealed a significant effect for the ratings of stimuli ( $p < .0001$ ). A Groups x Stimuli ANOVA was performed on absolute temperature change, and although no effect reached traditional acceptance levels, a marginal effect,  $F(1-16) = 3.47$ ,  $p < .08$ , was found for groups with a negative temperature change for the unsuccessful group and no change for the successful group.

**DOES HANDWRITING PREDICT DRUNKENNESS?: OBSERVATIONS FROM UNIVERSITY PARTIES.**

Steven W. Clarke\*, Michael J. Kalsher\*, Lisa C. Burnette\*, Melanie J. Bonner\*, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Seventy-six university students of legal drinking age attending a weekend fraternity party were asked to write a standard sentence and to sign their name when entering and prior to leaving the party. A sample of blood alcohol concentration was also obtained from each subject upon entering and leaving. All 76 "before/after" samples were randomly arranged for both sentence and signature samples. Research assistants were then asked to judge which sample of each "before/after" pair of sentences ( $n=33$ ) and of signatures ( $n=29$ ) was most impaired. The data show that accuracy of judgments increased at higher levels of exit BAC for both sentence and signature samples. Accuracy in judging sentences increased from 70.4% at BAC  $< .03$  to 93.1% at BAC  $> .12$ , whereas accuracy increased from 45% at BAC  $< .03$  to 90.3% at BAC  $> .12$  for signatures. The relative lower accuracy in judging signatures compared to sentences, particularly at lower levels of BAC, may be due to the fact that signing one's name is a well learned response that is relatively uninfluenced by level of impairment. However, the relative sensitivity of the sentence writing task may serve as a practical tool for assessing impairment in certain drinking situations.

A COMPARISON OF THE LONG-TERM EFFECTS OF DIAZEPAM, LORAZEPAM, AND BUSPIRONE ON SENSITIVITY TO A STRESSOR. T.L. Davidson, Dept. of Psych., Virginia Military Institute, Lexington, VA 24450. Although tranquilizers have been widely prescribed for short-term relief from anxiety, little is known about their effects on stressor sensitivity after drug use is discontinued. My research compared long-term effects among benzodiazepine tranquilizers diazepam and lorazepam, and a recently discovered nonbenzodiazepine tranquilizer, buspirone. In two studies, rats were injected with drug or saline prior to each of 12 daily sessions of food-reinforced bar pressing. Injections were then terminated, and three days later all rats received Pavlovian fear conditioning (no bar pressing) in which a 2 min tone signaled a mild shock. After 4 tone-shock pairings a day for 5 days, the capacity of the tone to disrupt bar pressing was assessed. Rats previously injected with diazepam or lorazepam were reliably more disrupted than saline controls. Buspirone injected rats did not differ from controls. The results suggest that one effect of benzodiazepines is hypersensitivity to stressors after drug use is terminated.

EFFECTS OF LONG-TERM CONTINUOUS INFUSION OF HALOPERIDOL ON EATING, DRINKING, AND ACTIVITY IN THE RAT. James R. DeMarco, Anthony G. DeMartino\*, Debra B. Hurtt, and Leonard E. Jarrard, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. Haloperidol, a dopamine antagonist, was injected into the third ventricle using Alzet osmotic minipumps. The pumps were filled with either haloperidol (5 mg in 1 ml) or saline and this amount was injected over a two-week period. Activity, eating, and drinking were monitored before, during, and after drug administration using a system that samples these behaviors every 5 sec. In addition, the amount of food and water consumed for each 24-hr. period was recorded. The results indicated that overall activity was not affected, but drinking was increased during the period of drug administration. Further, there were rebound effects on food and water consumption. These results will be discussed in terms of changes in the sensitization of synaptic receptors following a prolonged period of dopaminergic hypofunction.

SAFETY BELTS AND SEX: WHAT KIDS WATCH ON TV. Katrina J. Evans\*, Jennifer Gault\*, Robert E. Evans\*, Michael Kalsher\*, and E. Scott Geller, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., 24061. Several theories of behavior indicate that people model the behavior of their heroes or significant others, particularly children. This project highlights this phenomenon by taking observations of safety belt use and sexual behavior as portrayed on television. Safety belt use observations have been collected for the last four fall seasons on all three networks. Results of the safety belt use observations indicate a general trend towards increased use. It is significant that in 1984 hundreds of children signed and mailed a plea to producers and actors in Hollywood requesting that they buckle up when driving on television. Sexual behavior observations have only been collected for the current year. The dependent measures are designed to test whether or not television portrays sexual behavior in a responsible manner (i.e., do characters consider various risk factors associated with sexual contact).



**CORRELATES OF NUMBER OF RESPONSES TO MALE PERSONALS ADS: WHAT SELLS?** Chet H. Fischer, Dept. of Psy., Radford Univ., Radford, Va. 24142. Recently, personals ads have been touted as an increasingly popular method of meeting other eligible singles. However, empirical support for the effectiveness of personals advertisements is nonexistent. Fischer (1987) randomly sampled one hundred males and females who placed ads in a Wash., D.C. magazine. The results suggested that the advertisers were successful, educated, and interested in taking control of their dating lives. The present study questions what ad variables produce the greatest number of responses to the ads. Thirty-two of the returned male questionnaires were used in the present study. Correlational and multiple regression analysis were used to determine the relationship between the number of replies per ad and eighteen content variables mentioned in the ad. The results demonstrate that the number of responses are a) positively correlated with the length of the ad and b) negatively correlated with the age of the advertiser. Significance was not obtained for any of the other sixteen content variables. The implications of the findings were discussed.

**HEALTH EDUCATION IN THIRD WORLD COUNTRIES: ORT AND EPI IN NIGERIA.** Kent E. Glindemann\*, Robert E. Evans\*, E. Scott Geller, & Deanna L. Pendrey\*, Dept. of Psych., Va. Polytechnic Inst., Blacksburg, Va. 24061. The magnitude of child survival problems and the availability of new health technologies such as Oral Rehydration Therapy (ORT) and Expanded Programs of Immunization (EPI) have made it possible to mobilize social concern around the issue of child survival. Although many, if not most, developing countries in the world today have ORT or immunization programs, most of these programs are not meeting their expected goals. The focus of this ongoing project is to facilitate existing child survival programs in the development of new programs through the application of behavior analysis. The study targeted two health clinics in Nigeria (one urban, one rural). Indigenous health care workers were the agents through which the program was implemented. The focus of this program is to teach these health care workers how to communicate health education effectively to the native population. Results have thus far been promising, indicating the effectiveness of visual aids (e.g., flip charts) and other involving strategies in the communication of child survival strategies.

**DEVELOPMENT OF FGRSS: FEMALE GENDER-ROLE STRESS SCALE.** Shanette M. Harris, Dept. of Psych., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. A rationale was presented for the development of the Female Gender-Role Stress Scale (FGRSS), an instrument for predicting stressful situations for females. The FGRSS differentiates between males and females; correlates positively with traditional measures of stress and emotional outcomes of stress (e.g., anxiety, depression); and yields a low relationship with gender-role orientation measures. The FGRSS is discussed in terms of its factor structure and implications for assessment in psychology.

**FACETS OF SATISFACTION: SOCIAL CUES, TASK STRUCTURE, AND PREDISPOSITION.** Neil M. Hauenstein\* and Monnie L. Bittle\*. Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Job satisfaction has traditionally been examined as a function of either objective task characteristics or the social environment. More recently, focus has been given to the influence of one's predisposition to satisfaction or general sense of well-being. Each of these perspectives was evaluated within a simulated organizational setting by manipulating task characteristics (enriched vs unenriched) and social cues (positive vs negative) and measuring various aspects of one's predisposition to satisfaction. Results provided strongest support for the predispositional approach, especially when task characteristics were unenriched and social cues were negative.



ON THE ROLE OF NALOXONE IN RETENTION OF A PREOPERATIVELY LEARNED SPATIAL TASK IN HIPPOCAMPECTOMIZED RATS. Esther M. Huffman, Robert A. Forbes\*, Mary Ann Loftin\*, and Leonard E. Jarrard, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. Rats that have had the hippocampus removed by aspiration are impaired in their ability to remember spatial tasks learned before the operations. It has been reported that naloxone has a modulatory effect on memory, serving to improve acquisition and retrieval of information. In the experiment to be reported rats learned an 8-arm radial maze before the operations, half of the rats had the hippocampus removed by aspiration, and then on recovery the animals were tested for retention. One-half of the rats in each of the Hippocampal and Control groups were administered intraperitoneal injections of naloxone (5 mg/kg) approximately 20 min before daily testing, and the other animals received injections of saline. While performance of hippocampals was impaired relative to that of controls, naloxone did not differentially affect the number of errors made by either group. However, running time in both hippocampal and control rats was slower in naloxone than saline-injected control rats. The results indicate that naloxone does not serve to help hippocampal lesioned rats retrieve spatial information learned before the operations.

INTERFERENCE IN THE SPATIAL MEMORY OF ADULTS, CHILDREN, AND RATS. Debra B. Hurtt, Kyra T. Draves\*, and David G. Elmes, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. Theories of spatial memory predict minimal interference in the retention of a spatial habit. Our previous work with rats and adult humans showed that spatial retention is subject to both retroactive and proactive interference. In the present experiment, second- and fourth-grade children were tested for their retention of the spatial locations of pairs of cards in a concentration game. Compared to children who learned only one game, substantial retroactive interference was observed in children who had learned a second, interfering game. Contrary to expectation, second and fourth graders performed about the same in both learning and retaining the spatial locations. The entire pattern of results is congruent with the idea that regardless of the way in which spatial information is represented in the brain, it is subject to many of the interference processes that influence other forms of memory. (Supported by a R. E. Lee Research Grant.)

A FIELD EVALUATION OF MIXED DRINK AND BEER DRINKERS. David S. Levitt\*, Steven W. Clarke\*, Kent Glindemann\*, & Michael J. Kalsher\*, Virginia Polytechnic Institute & State University. Students of legal drinking age at a weekend fraternity party chose beer or mixed drinks to drink throughout the night. Unbeknownst to the partiers, drinkers were randomly assigned to either a regular alcohol content or low alcohol content version of their preferred beverage type. Drinking patterns observed at an earlier party suggested that the beneficial effects of serving low alcohol substitutes at college drinking parties may be eliminated due to an increased drinking rate among partiers consuming low-alcohol beer. Drinking rates at the present party were similar for both the low and regular alternatives within beverage type, but different between beverage type. However, exit BAC was significantly greater for those in the regular-alcohol conditions. The drinking rate for beer drinkers was significantly greater than for those consuming mixed drinks. These results suggest that under certain environmental conditions college partiers may increase their drinking rate when consuming low-alcohol beverages in order to reach desired levels of impairment. Thus, simply providing low alcohol beverages may not necessarily reduce impairment among students at college fraternity parties.

**FITNESS: ITS RELATION TO MENTALLY STRESSFUL TASKS,** Larry L. Lindsay, Dept. of Psy., Old Dominion Univ., Norfolk, VA, 23529-0053. Thirty male subjects between the ages of 18-35 were assigned to a specific fitness group, according to a self-assessment of their fitness level. The levels were an aerobically fit group, a weight lifting fit group, and a non fit group. Within each group the subjects' autonomic reactivity was measured in three time intervals (1 min. into task, 2 min. into task, 4 min. after task). There was a significant difference found between the two fit groups in relation to their diastolic pressure at the 1 min. into task interval. There were no other significant differences found between the fitness groups, but there were significant differences found within the different time intervals of the autonomic reactivity readings. Each physiological measure was analyzed with a 3 (time into task) x 3 (fitness groups) analysis of variance. There was also a State-Trait Anxiety Inventory used in the present experiment and there were no significant differences found between the fitness groups at either the state or trait anxiety level.

**BIOFEEDBACK-ASSISTED RELAXATION THERAPY FOR CHRONIC PAIN AND HYPERTENSION: PSYCHOLOGICAL MEASURES PREDICTING TREATMENT OUTCOME.** James C. Llewellyn, P.J. Mikulka, Old Dominion Univ., Norfolk, VA 23508, & H.W. Cole, VA Med. Ctr. Biofeedback-assisted relaxation therapy was investigated in order to identify reliable psychological and physiological predictors of successful (SSs) vs. non-successful (NSs) treatment outcome. Psychological differences between compliant (CCs) vs. non-compliant (NCs) subjects were investigated as well. Twelve outpatient veterans with hypertensive or chronic pain diagnoses served as subjects for a preliminary analysis. Initial data from 12 NCs were used as well. A battery of psychometric tests was given before and after the treatment protocol, which consisted of 10 weekly one-hour sessions of EMG and thermal biofeedback coupled with progressive muscle relaxation, diaphragmatic breathing, mantra use, and guided imagery. Treatment was successful for two-thirds of the subjects, by decrements of 5-10mm Hg for BP or 20% for subjective pain ratings. The results indicate first, that CCs could control EMG levels but not thermal; second, that NCs tend to score higher on an obsession-compulsion measure (O/C); and third, that SSs tend to have lower measures of depression, O/C, interpersonal difficulty, and positive symptoms (number and intensity) than NSs, at the completion of treatment.

**INTERVENING TO PROMOTE SAFETY BELT USE AMONG CHILDREN AND ADULTS AT A MONTESSORI SCHOOL.** Debbi McCarthy, Dept. of Psychology, Va Polytechnic Inst., Blacksburg, VA 24061. Two interventions were implemented at a local Montessori school, in an attempt to increase the safety belt use of both children and adults. Use of a participatory safety belt skit, targetted towards preschoolers, and the use of safety belt data collection/coloring books, aimed at primary school aged children, served as our interventions. Safety belt use increased an average of 28% over baseline for adults and 11% for children after the first intervention. For the second intervention, usage increased 6% over baseline for adults and 17% for children.

**SPATIAL LEARNING AS A FUNCTION OF DISTRIBUTION OF PRACTICE.** Michael L. McClung, Tracy A. Williams\*, & David G. Elmes, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. Distributed practice leads to more rapid learning and better retention than does massed practice in many tasks and species. Because animal spatial memory benefits from distributed practice, and because the data base concerning human spatial learning is slim, we undertook to determine the effects of massed and distributed practice on human spatial learning. In four experiments that involved a variety of spatial tasks learned under several repetition intervals, distributed practice had only a minor positive effect on performance. The lag effect, which is increasingly better learning with increases in the repetition interval, is ubiquitous in human verbal learning but was not apparent in spatial learning. At this point we are reluctant to accept the null hypothesis of no effect of distributed practice, because spatial learning is sensitive to other variables (e.g., interference) in a way similar to that shown by other forms of memory.



LOCUS OF CONTROL: WHAT IS REALLY BEING MEASURED? Curtis S. McKee, Department of Psychology, Radford University, Radford, Va. 24142  
The current study involved the administration of a scale designed by the researcher to ask in a direct manner whether or not persons believed that they could control forces such as luck, chance and fate that have traditionally been assumed to refer to external locus of control. The scale asked what had been considered obvious, and found that many persons do not construe luck, chance and fate in accord with the previous research assumptions or in accord with the denotations of the terms. Specifically, many persons apparently believe that they can exert control over luck, chance, fate and the inevitable. The investigation further considered specific correlates with the Rotter scale. The present research suggests that the measures of Internal - External Locus of Control may not be measuring what is intended by those who use such. It may also explain some of the problems in locus of control research.

FOOD DEPRIVATION-INDUCED ANALGESIA IN THE RAT. Brian R. McKenzie\* & T.L. Davidson, Dept. of Psych., Virginia Military Institute, Lexington, VA 24450. Endogenous opiate systems appear to mediate the analgesia induced by a broad range of stressful events. Our research investigated (1) whether or not analgesia was induced by food deprivation, and (2) the degree to which this analgesia was reversible by naloxone, a well-known opiate antagonist. Rats (N = 16) were assigned to four groups and were tested once following 24 hr food deprivation, and once when they were not food deprived, in counterbalanced order. Half of the rats received subcutaneous (sc) injections of 2.5 mg/kg naloxone when they were tested under food deprivation, whereas the remaining received isotonic (0.9% NaCl) saline. All rats received saline sc when tested nondeprived. Latency of reflexive tail-flick to a temperature stimulus served as the index of analgesia. The results indicated that food deprivation produced a naloxone-reversible analgesia. It was speculated that feeding disorders characterized by self-imposed restrictions of food intake may involve activation of the opiate system.

INCREASING SAFETY BELT USE IN THE COMMUNITY: AN INTERVENTION STRATEGY AT A SKATING RINK. Deanna L. Pendrey\*, Russell S. Eddins\*, Katrina J. Evans\*, and Robert E. Evans\*, Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., 24061. Baseline seatbelt use data was collected at a community skating rink before and after Virginia adopted a belt use law on January 1, 1988. Data analyses indicated an overall increase of 42 percentage points for adults and 41 percentage points for children in belt use in January compared with December's overall percentages. However, there was a decline in belt use of 25 percentage points for children and 17 percentage points for adults in February. When baseline data becomes stable, interventions designed to test the effectiveness of commitment strategies will be implemented to encourage belt use by children and adults.



## THE PREDICTABILITY OF EMPLOYEE INTENTIONS AND ATTITUDES TOWARD RETIREMENT.

Kerrie D. Quinn, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23508  
Making predictions about the age at which employees retire has become increasingly difficult over the past years. It was expected that different retirement intentions and attitudes would be found for employees in four age groups of faculty and staff employees, as a function of individuals' life satisfaction, job satisfaction, and demographic information. A survey containing Likert-type questions was sent to 380 employees of Old Dominion University. Responses were selected from 80 male and 80 female faculty and staff employees in each of the four age categories (30-40, 41-50, 51-60, and 61 and above). Pearson correlations and step-wise multiple regression analyses were performed. Results suggest predictors of intended retirement age and retirement attitudes are a function of the age and occupation of each employee. Overall, job satisfaction and a group of demographic variables were strong predictors of intended retirement age, while life satisfaction and approximately the same group of demographic variables were significant predictors of retirement attitudes. Future inquiry should direct itself to the examination of retirement intentions and attitudes, along with subsequent behaviors.

ACQUISITION OF A COMPLEX APPETITIVE CLASSICAL CONDITIONING TASK IN RATS WITH SELECTIVE IBOTENATE LESIONS OF THE HIPPOCAMPAL FORMATION. Kelly D. Shifflett, Matthew C. Pross\*, Rodger B. Cook\*, Terry L. Davidson & Leonard E. Jarrard, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. It has been reported that tasks requiring conditional responding are sensitive to hippocampal formation damage. Since these studies involved lesioning the hippocampus with conventional lesion techniques (aspiration, electrolytic), procedures known to damage more than just the hippocampus, we employed neurotoxin lesions (ibotenic acid). Following recovery from the operations, rats in the hippocampal, subiculum and control groups were trained on an appetitive, Pavlovian classical conditioning task using two conditional discrimination problems that differed in level of difficulty. Results indicated that hippocampal and subiculum lesioned rats were not impaired in acquiring conditional responding in either discrimination. These results differ from predictions based on current theories of hippocampal function.

AN EVALUATION OF HUMOR THERAPY FOR MATHEMATICS ANXIETY. Ashton D. Trice and Kimberly A. Elliott\*, Dept. of Psych., Mary Baldwin Col., Staunton, Va. 24401. Thirty-six women selected from the larger population ( $N = 84$ ) of enrollees in introductory psychology sections on the basis of high math anxiety scores on the Plake and Parker (1982) Revision of the Mathematics Anxiety Rating Scale (R-MARS) were randomly assigned to one of three statistical recitation sections. The statistical content of the course included descriptive statistics, correlation, z-scores, properties of the normal distribution, Chi-square, and  $t$ . Each section used semi-programmed materials, simple homework problems, and weekly didactic sessions. A control section involved no attempt to deal with the issue of math anxiety. One experimental section (attribution therapy), involved messages inserted into the text materials, emphasizing the student's ability and the simplicity of the tasks at hand. Similar messages were included in the didactic sections. The humor group included jokes and cartoons related to math inserted into the text, humorous contexts for the homework problems, and planned jokes and other humorous materials in class of both a general and mathematical nature. Positive changes in R-MARS scores were significant only in the humor group. Students in the humor group attended significantly more sessions and omitted fewer computation problems on the final exam than those in either the attribution therapy or control groups. Final exam grades were higher for the students in the humor group (82%) than for the attribution therapy group (78%) or the control condition (71%), although this difference was not statistically significant ( $p = .09$ ). These results suggest that humor may be a helpful adjunct to interventions with math anxiety in that it seems to help students with avoidance problems, but in itself humor has little effect on math performance.

LIFEGUARDS AS AGENTS IN MOTIVATING CHILDREN TO BUCKLE UP. Melissa Welch\*, Michael R. Gilmore\*, Robert E. Evans\* and E. Scott Geller, Virginia Polytechnic Institute and State University. A community program to encourage safety belt use by adults and children at three swimming pools was implemented during the summer months of 1987. The effectiveness of various promotional materials distributed by lifeguards was measured. Additionally, each pool was exposed to a different incentive and reward condition. At one pool, patrons, especially children, were rewarded when they displayed a pledge to buckle up card in their car. At another pool, patrons were rewarded if they displayed the pledge card and wore their safety belts. At the last pool, the lifeguards were rewarded for each increment of 10 pledge cards mailed in by patrons and received by the researchers. Results indicate that all conditions impacted upon safety belt use, but the commitment strategy (rewards for pledging) resulted in the highest withdrawal use rates when compared to baseline.

THE CONTEMPLATION OF SUICIDE: ITS RELATIONSHIP TO IRRATIONAL BELIEFS IN A CLIENT SAMPLE AND THE IMPLICATIONS FOR LONG RANGE SUICIDE PREVENTION. Paul J. Woods, Ph.D.\* & Geri E. Muller\*, Hollins College, VA 24020. Differences in underlying irrational belief systems between clients in psychotherapy who reported they were contemplating suicide (n=85) and those who reported they were not (n=122) were studied. The sample was over 95% of persons aged 16 and over seen for psychotherapy over a six-year period. Those contemplating suicide were significantly more irrational with the general composite picture being that of an individual who sees him/herself as a helpless victim of past and present circumstances who must, nevertheless, perform well, be approved of, and never have anything go wrong; any kind of failure would be awful for it would prove one to be a worthless person. Findings are consistent with other cognitive-behavioral research on suicide. Other approaches to the explanation of suicide are reviewed and criticized especially those which in Rational-Emotive Therapy terms have made an "A-C error."

DETERMINANTS OF VEHICLE SPEED IN A RURAL SCHOOL ZONE: EFFECTS OF GENDER, SAFETY BELT USE AND SPEED LIMIT SIGNS. Linford J. Yoder, & Galen R. Lehman, Dept. of Psychology, Eastern Mennonite College, Harrisonburg, VA 22801. A field study was conducted in response to parents concern about the speed of motorists passing by a rural elementary school. Although no data had been collected, the parents signed a petition to have a sign posted and the speed limit reduced. This study examined the speed of motor vehicles passing by school where the speed limit was 55 mph. Observers also recorded the gender of drivers and passengers and their safety belt use. The direct observations were checked for inter-observer reliability (91%). There were 331 speed recordings and 780 observations of safety belt use. The results indicate that the average speed of passing vehicles was 31 mph. There was no significant difference in speed between male and female drivers nor for safety belt users vs. nonusers. The results were given to the highway engineer with a recommendation that a speed limit sign be posted. If such a sign is posted, follow up data will be collected to see if the sign makes a difference. The results also indicate that this particular school would be a good target population for a safety belt intervention since only 24% of the male drivers and 29% of the children were observed using their safety belt.

## Statistics

INFERENCE IN ROBUST REGRESSION. David B. Agard and Jeffrey B. Birch, Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va 24060. In the general linear model (GLM) robust M-estimation of parameters has been studied extensively in recent years. It has been demonstrated that M-estimation provides efficient estimation of parameters when outliers are present in the data. However robust inference using M-estimators has received relatively little attention. A robust inferential procedure would provide robust alternatives to the usual statistical analyses associated with the general linear model which include estimation of parameters and standard errors, diagnostic checks, and the construction of confidence intervals and hypothesis tests. This robust GLM will be designed to be robust to outliers where outliers are described as anomalous observations not fitting the pattern expressed by the remainder of the data. In robust inference we desire tests that maintain appropriate size yet show good power when the data contain outliers. Several proposals are discussed and their properties examined through simulation across a variety of contamination in the error distribution.

### PORTFOLIOS WITH LESS THAN MINIMUM VARIANCE

J. V. Bowen, Department of Mathematics, University of Richmond

The Mankowitz portfolio is one in which the asset allocation has been made to minimize the variance of a portfolio subject to a target (historical) total return. No provision is made for sale, purchase, or exchange of equities. A nonparametric estimate of 'flood level' of the portfolio is used to initiate a short term trading strategy which increases the total return and simultaneously reduces the volatility of the portfolio from its original 'minimum variance'.

CONFIDENCE INTERVALS FOR A BINOMIAL PROPORTION. Timothy J. Breen, Dept. of Biostatistics, Medical College of Virginia / Virginia Commonwealth Univ., Richmond, Va. 23298. Several commonly taught procedures for obtaining confidence limits for a binomial proportion will be considered. The true confidence coefficients will be examined. A refined version of the Clopper-Pearson procedure will be proposed.

A STATISTICAL APPROACH TO THE CONSTRUCTION AND ANALYSIS OF ISOBOLOGRAMS. W. H. Carter, Jr., C. Gennings, E. D. Campbell, K. L. White, Jr., Department of Biostatistics, Va Commonwealth Univ., Richmond, VA 23298-0032. An isobologram is a contour of constant response on the dose response surface associated with a combination of drugs. Pharmacologists have found such plots useful in characterizing the nature of the interaction between pairs of drugs. However, the inferences drawn from these figures using ad hoc methods are often erroneous. The purpose of this research is to develop a method of constructing an isobologram so that the inferences drawn will have statistical validity. Some comments will be made on extending this methodology so that it will apply to multi-drug combinations.



**LARGE DEVIATION LOCAL LIMIT THEOREMS FOR RATIO RANDOM VARIABLES.** N. R. Chaganty, & Sanjeev Sabnis\*, Old Dominion University, Norfolk, Va. 23529. Let  $\{R_n, n \geq 1\}$  be a sequence of random variables with probability density functions  $\{g_n, n \geq 1\}$ . Assume that  $R_n \rightarrow c$  in probability for some constant  $c$ . Let  $\{r_n, n \geq 1\}$  be a sequence of real numbers bounded away from  $c$ . An asymptotic expression or the limit of  $g_n(r_n)$  is known as a Large deviation local limit theorem. The event  $\{R_n \geq r_n\}$  is known as a large deviation event. In this paper we present large deviation local limit theorems for ratio statistics  $R_n = T_n/S_n$ , where  $\{T_n, n \geq 1\}$  is independent of  $\{S_n > 0, n \geq 1\}$ . We also consider the case where  $\{T_n, n \geq 1\}$  is a random vector and  $S_n$  is a positive random variable and obtain multidimensional large deviation local limit theorems for the ratio  $T_n/S_n$ . We present some examples to illustrate our theorems.

**ON THE RELATIONSHIP BETWEEN MEASUREMENT-THEORETIC INVARIANCE AND STATISTICAL INVARIANCE.** Ching-Yuan Chiang, Dept. of Math. & Computer Sci., James Madison Univ., Harrisonburg, Va. 22807. We point that, if measurement scales are considered as random variables, invariant operations in measurement lead to familiar concepts of invariance in statistics. Specifically, reference invariance corresponds to equivariance which is especially important in estimation, and absolute invariance corresponds to the invariance especially important in hypotheses testing. (Supported by James Madison Univ. Program of Grants for Faculty Research.)

**THE ANALYSIS OF A K-DIMENSIONAL ISOBOLOGRAM USING A PARALLEL COORDINATE SYSTEM.** C. Gennings, K. S. Dawson, W. H. Carter, Jr., Dept. of Biostat., Va. Commonwealth Univ., Richmond, VA 23298-0032. In the study of combinations of  $K$  drugs,  $K + 1$  dimensions are required to plot the dose-response relationship. Consequently, the production of informative plots of these relationships in the usual Cartesian coordinate system is difficult if not impossible when  $K \geq 3$ . A plot of a contour of constant response, or an isobologram, has been shown to be useful in characterizing and detecting interactions between the drugs. It is the purpose of this paper to demonstrate the usefulness of a parallel coordinate system to extend the construction of isobolograms to the combination of  $K$  drugs. Several examples will be presented and their interpretation discussed.

**AN EMPIRICAL STUDY FOR DETECTION OF OUTLIERS AND INFLUENTIAL OBSERVATIONS IN LINEAR REGRESSION MODELS.** Anwar Hossain and D.N. Naik Dept. of Math. and Stat., Old Dominion Univ., Norfolk, VA 23529. A large number of statistics are used, in the literature, to detect outliers and influential observation in the linear regression model. Two kinds of comparison studies to determine an optimal statistics are done (i) using several data sets studied by different authors, and (ii) a detailed simulation study. Different choices of the design matrix of the regression model are considered to study the performance in the case of multicollinearity and other situations. Calibration points using exact distributions and Bonferroni inequality are given for each statistics. The results show that, generally, we need a set of two or three statistics to detect outliers and a different set to detect influential observations. We suggest some simple modification of the available statistics which performs reasonably well in many cases.

**PROPERTIES OF HOTELLING'S  $T^2$  UNDER MISSPECIFICATION.** D. R. Jensen, Dept. of Statistics, Va. Polytechnic Inst., Blacksburg, Va. 24061, & D. E. Ramirez, Dept. of Mathematics, Univ. of Va., Charlottesville, Va. 22903. Properties of Hotelling's (1931)  $T^2$  are studied under misspecification of location and scale in the model for a multivariate experiment. Effects of dispersion parameters on the power of  $T^2$  are investigated, and the class of all dispersion-diminishing congruences is characterized. Stochastic bounds on  $T^2$ , and further properties of the  $T^2$  test, are studied under misspecification of the location and scale structure of a model. Applications are noted in the analysis of repeated measurements, in personnel selection, and in statistical process control using  $T^2$  charts.

#### BAYESIAN SAMPLING STRATEGY

Sean F. Keller\*, University of Richmond

Currently, utilities annually sample meters from each of many lots, and from that sample test the hypothesis that the mean number of defectives is under three percent. However, if one implements a Bayesian sampling/testing procedure and uses a beta prior, a much improved picture of the current proportion of defectives is had.

**DETECTING INTERACTIONS IN  $2^t$  PARAMETER DESIGNS.** Sang Ik Kim,\* Klaus H. Hinkelmann, Dept. of Statistics, V.P.I. & S.U., Blacksburg, VA 24061. Most traditional quality control activities using control charts cannot be used successfully to reduce the product variability due to uncontrollable noise factors such as production deterioration, manufacturing imperfections and environmental factors. A parameter design introduced by Taguchi is a new quality control method which can reduce such variation cost-effectively. This experimental design technique identifies an optimal setting of control factors which is least sensitive to the various noise factors. However, Taguchi utilized only main effects of control factors by using orthogonal arrays, disregarding any interaction effects. New parameter designs for  $2^t$  factorials of control factors will be developed using a partially balanced array. These new designs are characterized by a small number of runs and some balancedness property of variance-covariance matrix of the estimates of main effects and two-factor interactions. Techniques for analyzing the new designs will be discussed.

**ADAPTIVE RANK REGRESSION.** Daijin Ko, Dept. of Biostat., Va. Commonwealth Univ., Richmond, Va. 23298-0032. A class of M-estimators corresponding to rank regression estimators is introduced in which the weight function is a function of the error distribution F. The corresponding class of adaptive M-estimators is studied in which the distribution function F is replaced by an estimate  $\hat{F}$ . They are shown to have some attractive efficiency properties over a range of error distributions and robustness property against gross errors and skewness.

**ILL-CONDITIONED INFORMATION MATRICES AND THE GENERALIZED LINEAR MODEL: AN ASYMPTOTICALLY BIASED APPROACH.** Brian D. Marx & Eric P. Smith, Dept. of Stat., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. In the framework of the generalized linear model (Nelder and Wedderburn (1972)), iterative maximum likelihood parameter estimation is employed via the method of scoring. Entangled in this iterative procedure is a key matrix, the information matrix. Ill-conditioning of the information matrix results in unattainable desirable properties for the parameter estimates. Some alternatives to maximum likelihood estimation are put forth which alleviate the detrimental effects of near singular information.



TWO-DIMENSIONAL DESIGN FOR CORRELATED ERRORS. John P. Morgan, Dept. of Math. and Stat., Old Dominion Univ., Norfolk, Va. 23529, and Nizam Uddin\*, Dept. of Math. and Stat., Old Dominion Univ., Norfolk, Va. 23529. Optimal two-dimensional designs are constructed for correlated errors on the torus. The method depends on appropriate partitions of the finite field of order  $v$ , where the number of treatments  $v$  is a prime power, producing series of connectable planar squares. Near optimal designs are constructed for other small values of  $v$ . Most of the designs are for second order processes, but some higher order results are obtained as well. A few calculations are made for planar versions of the designs.

#### PREDICTION INTERVALS FOR SYMMETRIC NORMAL VARIABLES.

D. N. Naik, Dept. of Math. & Stat., Old Dominion Univ., Norfolk, Va. 23529. Prediction interval for  $y_{n+1}$  based

on  $y_1, \dots, y_n$  is obtained when  $y_i \sim N(\mu, \sigma^2)$ ,  $i=1, \dots, n+1$ ,

and  $\text{cov}(y_i, y_j) = \rho \sigma^2$ ,  $i \neq j$ . The results are generalized

to the linear regression models with equicorrelated errors. The intervals obtained in these cases are observed to be the same as in the case where variables are uncorrelated. This fact indicates that the usual prediction intervals obtained when variables are uncorrelated, are robust against the equicorrelated case.

BAYESIAN TESTING OF AN EXPONENTIAL POINT NULL HYPOTHESIS. Patricia A. Pepple, Department of Mathematical Sciences, Virginia Commonwealth University, Richmond, Va. 23284-2014. The problem of testing a point null hypothesis involving an exponential mean is investigated with the objective of demonstrating that the usual interpretation of P-values as evidence against precise hypotheses is faulty. As in Berger and Delampady (1986) and Berger and Sellke (1987), lower bounds on Bayesian measures of evidence over wide classes of priors are found emphasizing the conflict between posterior probabilities and P-values. A hierarchical Bayes approach is also considered as an alternative to computing lower bounds and "automatic" Bayesian significance tests which further illustrates the point that P-values are highly misleading measures of evidence for tests of point null hypotheses.

RANK-BASED PROCEDURES FOR TIME SERIES ANALYSIS. Madan L. Puri\*, Indiana Univ. and Virginia Polytechnic Institute and State University. The problem of testing randomness against specified and unspecified contiguous ARMA alternatives is considered. In the case of a specified alternative, the linear serial rank tests proposed by Hallin, Ingenbleek and Puri [*Ann. Statist.* 13(1985):1156-1181] are shown to be asymptotically most powerful within the class of all possible tests (at the required level). In the case of an unspecified alternative, however, any of the above optimal tests is completely insensitive against a whole subclass of the alternative. Quadratic serial rank statistics, providing tests of the  $\chi^2$ -type are therefore introduced. Their asymptotic distributions are derived, under the null hypothesis as well as under contiguous ARMA alternatives. The asymptotically maximin most powerful quadratic serial rank tests (for a given density) are then obtained. Because of their close similarity with the Box-Pierce parametric test, we call them rank portmanteau tests. The asymptotic relative efficiencies (AREs) of the rank portmanteau tests with respect to one another and their asymptotic relative efficiencies with respect to the corresponding Box-Pierce and quadratic Spearman tests are derived.



A SIMPLER PROOF FOR A RESULT OF GLESER & OLKIN. Rana P. Singh, Department of Mathematics, Virginia State University, Petersburg, Virginia 23803.

Following result is used in deriving the asymptotic non-central distribution of the likelihood-ratio statistic for testing the equality of vector parameters of a k-sample regression model with covariance:

If  $L = (\ell_{ij}) : a \times b$  and  $C : c \times a$ , then

$$\sum_{i=1}^a \sum_{j=1}^b \left( \frac{\partial \log |W|}{\partial \ell_{ij}} \right)^2 = 4 \text{tr} L L^T (C^T W^{-1} C)^2,$$

where  $W = I + C L L^T C^T$ .

Gleser & Olkin [In *Multivariate Analysis* (P. R. Krishnaiah, Ed.), Academic Press, New York, 59-72, (1966)] provide the proof of this result by using elementwise differentiation of a scalar function of a matrix, which is quite lengthy and involved. The aim of this paper is to use differentials, a matrix differentiation result and a trace property to provide a very easy proof of the above theorem. Additional applications of this approach will be pointed out.

#### SOME CONSTRUCTIONS FOR BIB AND PBIB NESTED ROW- COLUMN

DESIGNS. Nizam Uddin\* & John P. Morgan, Dept. of Math. and Stat., Old Dominion Univ., Norfolk, Va. 23529. Construction of balanced and partially balanced incomplete block designs with nested rows and columns (BIB-RCs and PBIB-RCs) is considered. A general method of construction of BIB-RCs is developed using difference techniques, from which some infinite series are obtained. The method also produces PBIB-RCs based on the pseudocyclic association scheme. A number of constructions of PBIB-RCs based on Latin square and rectangular association schemes are also presented.

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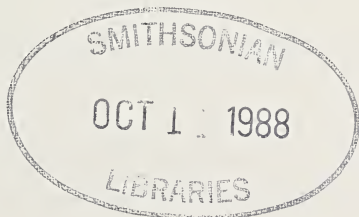
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## Fall 1988

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## EDITOR'S NOTE

This is a happy day for The Journal. This is the first issue since Volume 32 Number 4 (the last issue of 1981) which has typeset appearance. In 1981, the increased costs of publishing a scientific quarterly forced an unwelcomed decision on the academy--the change to printing camera-ready manuscripts. Today, even with the constant cost increases in paper, printing and postage, the increase in dues and the availability of desk top publishing technology has allowed us to change back to typeset appearance.

My college administration has offered continuous encouragement and support for my efforts with the Journal. We owe special thanks to The Division of Engineering and Applied Sciences, J. Sargeant Reynolds Community College which has supplied the computers and programs needed to translate and process manuscripts and the laser printer which produces page masters.

## **The AIDS Epidemic in 1988**

**John C. Petricciani, M.D., Deputy Director  
National AIDS Program, U. S. Public Health Service**

**Presented to the Virginia Academy of Science  
Charlottesville, VA, 25 May 1988**

I appreciate the opportunity to be with you this evening and for the honor of presenting the Sidney S. Negus Memorial Lecture.

My purpose tonight is to point out how AIDS, more than any other event in the recent past, has made us appreciate the impact of science on public policy and the interdependency of the two. I'll start out by bringing you up to date on where we are nationally with the epidemic, including some of the initiatives taken by the Public Health Service, and then finish up with a discussion of a major scientific and policy issue that is still unsettled.

First . . . a little history to put this into perspective.

Almost seven years ago, in June of 1981, the Public Health Service published the first reports of 5 cases of *Pneumocystis Carinii* pneumonia. They all occurred in Los Angeles.

Now, 5 cases aren't many --- but this clustering of a very unusual disease made the epidemiologists curious, and alerted them to the possibility that something out of the ordinary was going on.

Then a month later, the Public Health Service reported that 26 young men had been diagnosed with a very uncommon type of cancer called Kaposi's sarcoma.

During that same month another 10 reports of *Pneumocystis* in several other cities had trickled in to our Centers for Disease Control in Atlanta. But there was something else that caught people's attention . . . all 15 cases of pneumonia and 26 cases of cancer had occurred in young homosexual men.

Something strange was going on.

As more effort went into trying to figure out this puzzle, medical investigators began to see an even more complicated picture than they suspected at first.

Not only were people developing those rare cancers and pneumonias, they were dying of them because they were unable to fight back. For some reason, their immune systems had been destroyed and were no longer able to function normally.

In other words, their immune systems had become deficient.

But these immune deficiencies were not based on genetics like the ones we were used to seeing in children. The immune problems of these young men were somehow acquired in adult life. And that's where we got the name for this disease: Acquired Immune Deficiency Syndrome. Soon everyone settled just for the initials: AIDS.



That was in 1981. And it's been AIDS ever since.

A lot's happened since then --- to put it mildly! But let me touch on just a few of the main facts that we've learned over the past 7 years.

First, AIDS is caused by a virus called HIV, which stands for the "Human Immunodeficiency Virus". It was discovered in the United States by Dr. Gallo who works for the Public Health Service at the National Cancer Institute, and in France by Dr. Montagnier at the Pasteur Institute.

Since those discoveries in 1983/1984, an enormous amount has been learned about the virus itself and about the disease. First of all, we now know a great deal about what happens after a person becomes infected with HIV. And I'd like to spend a few minutes on this information because it is so vital to how we feel about the disease and what we as individuals do about it in our own lives.

Like other viruses, once HIV gets past the outside barriers of the body, it finds susceptible cells, reproduces itself, and then goes on to infect other cells. Nothing too unusual about that. But in the process of infecting cells, the AIDS virus turns its RNA genetic material into DNA, and then integrates itself into the chromosomes of the cell.

That's not only unusual for human viruses, but it also complicates the whole strategy of how to deal with the infection because the virus can remain dormant in the chromosomes of some of the infected cells where it then can act as a quiet reservoir capable of replicating and releasing infectious virus at any time in the future.

Other infected cells synthesize and release large amounts of new virus. Normally after 6 to 12 weeks the immune system detects the proteins of the AIDS virus and begins to make antibodies. A few people apparently have taken as long as 6 and even 30 months to make antibodies, but those studies need to be confirmed. If it is a real phenomena, then it must be rare or we should be seeing many more transfusion related cases of AIDS than have actually occurred.

Antibodies to the AIDS virus have been the key to understanding both the scope of the epidemic and how we might control it because they provide a means of identifying persons who have been infected with HIV at some time in the past. But antibody tests do not give direct information about *when* a person was infected.

Unfortunately, as far as we know today, the presence of antibodies does not mean that the body can eliminate the virus as is the case for most other infections. One of the problems is that by the time antibodies are produced, the virus has already set up shop in various cells throughout the body. And instead of eliminating the infection, we find that the AIDS virus and antibody co-exist.

It is for this reason that the detection of antibodies implies at least some chance that the person is also carrying infectious virus in blood, semen, or vaginal fluids. But remember that the antibody test is useful in detecting infected persons only *after* they've formed antibodies --- usually 6 to 12 weeks after they were originally exposed to the virus.

In practical terms, that means that if the antibody test is run too early after an exposure, negative results are not going to mean anything. Before anyone begins to hang his hat on a negative antibody test result, at least 12 weeks should have passed from the time of exposure in order to give enough time for the antibodies to form.

The first major application of the antibody test was in screening blood and plasma donations as a public health measure to increase the safety of blood and blood products. A great deal was learned from that experience, and those lessons continue to be valuable as the use of the test expands to other population groups.

Since testing began in early 1985, over 30 million units of blood have been screened. That means at least 3000 infected persons have been identified as HIV antibody positive, were informed of the results, and were counselled. But equally important from a public health point of view is the fact that several thousand citizens who were in need of blood and blood components were spared from the AIDS virus.

Unfortunately, like any other biological system, the screening test isn't perfect and a very small number of transfusion associated infections have occurred because antibody had not yet formed in infected donors when the screening was done. In other words, the results of the screening test were falsely negative.

It is also important to realize that while this is a technical problem, it is also a reflection of the larger problem of *new* AIDS infections because these false negative screening test results are only associated with a *newly* infected person. And as I mentioned earlier, that period usually is limited to 6 to 12 weeks after being infected with the AIDS virus. That is one of the major reasons for urging people at risk for AIDS *not* to donate blood. Anyone --- including physicians --- who encourages people to go to a blood bank to find out if they are infected with HIV is contributing to the problem and must assume part of the responsibility for any new transfusion associated cases that may occur as a result.

Knowledge about the virus and its life cycle has put us on the road to developing drugs to prevent people who are already infected from getting sick, and to developing a vaccine to prevent more people from getting infected in the first place. This year, for example, the Public Health Service is spending \$176M on drug development and \$62M on vaccine research. And Secretary Bowen has requested even more in next year's budget which was submitted to Congress recently: \$243M for drug research and \$93M for vaccines.

But even though there's been some real progress in drug and vaccine development, it's probably going to be some time before we see substantial improvements over what's now available. And for practical purposes that means we're limited to AZT. As a result, for the present we've got to rely on nonmedical strategies to keep the epidemic from getting worse than it already is.

Well, how bad is it? One of the things that the Public Health Service has traditionally done is keep track of disease trends. AIDS has certainly been no exception in that regard, and the CDC has been reporting this kind of information since AIDS was first recognized as a public health problem.

From the first 5 cases reported in 1981, the number has grown to over 60,000 at the present time. And more than half of those people have already died. As bad as that is . . . and it's hard to argue that that's not bad news . . . it's only part of the gloomy side of AIDS in the U.S. in 1988.

The Public Health Service along with State and local health departments and universities throughout the country have put together a pretty accurate picture of the disease as it's unfolded over the past 7 years. The bottom line is that



the 60,000 cases of AIDS that I mentioned a few minutes ago represent just a fraction of the people who are infected with the virus.

There are many, many more people who have been infected but who are not sick --- at least not yet. In plain terms that means there are probably over a million people in the U.S. today who are carrying the virus, who are not sick, but who can pass it on to others. That's the really bad news!

The other part of the picture that makes it especially difficult is that AIDS is an infectious disease transmitted through sexual contact. It's also transmitted by blood, but it is the sexual route of transmission that has caused us as a society so much difficulty in coming to grips with the disease and with strategies to prevent it's further spread.

Let me illustrate the point. Most of you would not have even cared, much less have been offended, if in my opening remarks tonight I told you that I had been given a shot of penicillin this morning for a strep throat and that I wasn't feeling too well this evening. Just think what your reaction would have been, if I told you that I had been given the penicillin for gonorrhea.

We usually talk openly about virtually any other kind of infection, but we just don't deal very well with discussions of sex or of sexually transmitted diseases.

Compounding the issue with AIDS is the fact that just a few years ago we were primarily focussing our attention on gay men in San Francisco, Los Angeles, and New York City. Homosexuality, anal sex, bisexuality, and finally drug abuse suddenly became linked in the public's mind with AIDS.

As a result, people got the mistaken impression that AIDS was a problem for someone else, somewhere else. Or put another way, most people began to think: "It isn't my problem and it couldn't happen here in my town, so what's there to worry about?"

Unfortunately, we concentrated on high risk GROUPS instead of high risk ACTIVITIES. The real point is that it doesn't make any difference at all what label you wear, but it does make a life and death difference WHAT you do and WHO you do it with.

Well, it turned out that the AIDS virus behaved no differently than anyone familiar with sexually transmitted diseases would have guessed. And that is, it spread. It spread geographically and it spread among different subgroups. Not only in our society but throughout the world.

Today, over 20 of our major cities have each reported more than 400 cases of AIDS. And one or more cases have been reported in all 50 States. Here in Virginia there have been over 700 cases since 1981, and 300 of those were reported in 1988.

Another concern is the rise in AIDS among blacks and hispanics. Blacks account for 12% of the population, but they account for 25% of all AIDS cases. Similarly, hispanics account for 6% of the U.S. population, but they make up 14% of all AIDS cases. Leaders of these minority communities were initially reluctant to admit AIDS was a problem for them, but many have now recognized the seriousness of the situation and are willing to address it.

And if we look at the global situation, it's the same picture except on a larger scale. Over 130 countries have reported cases to the World Health Organization, and WHO estimates that at the present time there may be as many as 10 to 15 million people infected worldwide.



Another grim fact that we've learned since 1981 is that AIDS is a fatal disease for the vast majority who get it. As of today, about 90% of the patients diagnosed in 1981 are dead. We also know that AIDS is a devastating disease for patients, their loved ones, and for the medical profession itself. Some people may die relatively quickly in a matter of a few weeks or a few months . . . or death can come slowly over the course of several years with numerous complications along the way. In a word, AIDS is a physically and psychologically destructive disease for all who are touched by it. It is relentless and lethal, and we have every reason to try to check its spread.

And that leads to a very important question: just how did this disease get from 5 cases in 1981 to over 60,000 at present? First of all, AIDS --- like any other infectious disease --- does not respect artificial boundaries such as sexual preference, religious affiliation, or even political party. Although we often find it convenient to think of society in terms of well-defined groups with no overlap, the reality of the human condition is vastly different from such a simple model. For example, it's been made abundantly clear to all of us that some married men occasionally have sex outside of marriage and even with a prostitute. But in addition, we've had to come to grips with the reality of some gay men having sex with women, some married men occasionally have sex with other men, and some men in both of those groups being drug abusers. Because of these as well as other aspects of the human condition, AIDS was bound to spread. The only question was how fast and how far.

What we see today in terms of AIDS cases really reflects infections that occurred as long ago as 7 years or even longer --- and that means 1981 or earlier, a time when we were just beginning to see that there was a problem. AIDS does not occur overnight. It takes time for the virus to begin to show its destructive effects even though undetectable and progressive changes are taking place in infected people who appear to be well. To put that into perspective, let me point out that 3 years after infection only about 5% have AIDS, and after 7 years it's only about 35%.

But talking in terms of percentages obscures some very important information. For example, about 4% of all reported AIDS cases have been traced to heterosexual contacts. That's a small percentage, but it's climbing. And even at 4%, it means that over 2,000 men and women in the U.S. have developed AIDS as a result of heterosexual contact. That's more than the total number of cases in every country in Western Europe except France which has just over 3,000! But again, let me remind you that this is a snapshot of what went on during the last 7 or more years. The implications of that are pretty sobering: when you have sex with someone today, you're *also* potentially having sex with *everyone else* that person has had sex with for the past seven years, or perhaps even longer.

That's why the Surgeon General was so explicit in his recommendations about the use of condoms for people who decide to have sex with someone outside of a monogamous relationship. It was public health advice based on a recognition of what goes on in real life, and what limited preventions are available at the present time. He did not suggest that condoms were 100% effective, but he did say that they're better than nothing at all.

A few moments ago I mentioned that for the immediate future we have to rely on non-medical means to stop the spread of AIDS. By that I mean we have to give people the facts about AIDS, and try to persuade them to protect themselves from getting infected.

The public needs information on how it **IS** spread, and how it is **NOT** spread. We need to make clear what we **DO** know about it, and what we **DON'T** know. And finally, we have to rely on an educated public to take charge of their own health by acting in a responsible way based on knowing the facts.

Complicating this approach --- which is basically the only game in town right now --- is a fair amount of misinformation and actual disinformation.

From the very start of this epidemic we've been concerned about not only **HOW** it's spread, but how **EASILY** it's spread. Now, after several years of critical followup studies both here in the U.S. and in other countries, we have a good idea about how risky it is to be in normal social and work contact with someone who's infected with the AIDS virus. And we can say some pretty definite things about how you **CAN** get it and how you **CAN'T**.

You **DON'T** get AIDS from shaking hands, hugging, or from social kissing. You **DON'T** get it from restaurants, drinking fountains, bath towels, or toilets. In short, AIDS is not a highly contagious disease, and in the vast majority of cases it's transmitted in essentially two ways: through sex & through direct exposure to blood. And the reason for that is not too difficult to understand. It's only in blood, semen, and vaginal secretions that HIV has been found consistently and in high enough concentrations to be effectively transmitted.

Saliva is probably not an important means by which the AIDS virus is spread; but at this point in time we can't rule out the remote possibility that it happens under certain conditions. The reason we're relatively secure in this point of view on saliva is that no transmissions have occurred in health care workers who were exposed to saliva of AIDS patients. If transmission does occur by saliva, it's probably infrequent and a minor risk in comparison to sex and blood.

Another problem is where **LACK** of information has led to fear and virtual panic. Here I'm thinking specifically of situations in schools where students with AIDS have encountered problems. There is probably no more compelling illustration of this than the case of Ryan White, an adolescent hemophiliac. He recently testified before the President's Commission on AIDS, and I'd like to share some of his comments to them with you.

"The school I was going to said they had no guidelines for a person with AIDS. The school board, my teachers, and my principal voted to keep me out of the class room even after the guidelines were set for fear of someone getting AIDS from me by casual contact. Rumors of sneezing, kissing, tears, sweat, and saliva spreading AIDS caused people to panic.

"We began a series of court battles for 9 months. Eventually I won the right to attend school, but the prejudice was still there. Listening to medical facts was not enough. People wanted 100% guarantees.

"Even though we knew that AIDS was not spread by casual contact, parents of 20 students started their own school. Because of the lack of education on AIDS, discrimination, fear, panic, and lies surrounded me. I became the target of Ryan White jokes. Lies were spread about me biting people, spitting on food, and urinating on bathroom walls. Some restaurants threw away my dishes.



My school locker was vandalized inside and folders were marked FAG and other obscenities.

"I was labeled a trouble-maker, my mom an unfit mother, and I was not welcome anywhere. People would get up and leave, so they would not have to sit anywhere near me. Even at Church, people would not shake my hand.

"In 1987 my family and I decided to move to Cicero, Indiana. For the first time in 3 years we feel we have a home, a supportive school, and lots of friends. I'm just one of the kids, and all because the students at Hamilton Heights High School listened to the facts, educated their parents and themselves, and believed in me."

There are a lot of messages in what Ryan told the Commission; but the one I want to stress here is that information, education, and policy development are likely to be much more effective **BEFORE** there's a case of AIDS than if they have to be put in place after there's already a problem. And this is just as true for AIDS in the workplace or in other institutions as it is in schools.

At the Federal level we've been working with the Office of Personnel Management to develop guidelines for the U.S. Government workplace. And I'm glad to be able to tell you that there is now a policy in place which essentially says that AIDS is no different than many other conditions, and that education programs must be developed to give Government employees the facts not only about AIDS, but about personnel policy regarding AIDS at work. Now let me get back to the issue of public information and education, and bring you up to date on what we've done so far and what we have planned in the near future.

First of all, it's important to keep in mind that there is an underlying purpose to all of these information and education efforts, and that is to get people to modify their **ATTITUDES** and their **BEHAVIOR** --- IF & WHEN they need to be --- in order to deal with all the many aspects of AIDS in a positive, healthy, and helpful way. That's obviously a tall order, and there's a lot of experience accumulated so far that tells us we haven't been as effective as we would have hoped. But, we need to keep trying and to keep improving our strategies.

At the Federal level the major source of public information about AIDS has been the Surgeon General's Report. That was prepared at the request of the President, and was first published in 1986. We've distributed over 14 million copies since then, and virtually all the feedback we've had on it has been positive.

As a followup to that report, the Public Health Service has prepared another general information brochure that has started going out in the mail today to every household in the United States. That means over 100 million copies! It will be along the same general lines as the Surgeon General's Report, but will be more condensed and easier to read. In addition, we'll be increasing our public service announcements on radio and TV to draw more attention to the brochure.

Now for most people that kind of basic information is enough. But others -- and here we're literally talking about millions of people --- want and need more details. They not only want information, they want to be educated about AIDS. That's not an easy thing to handle at the national level, and I think most people would agree that education is going to be most effective when it's done at the local level.



As a start, though, in 1983 we established a national AIDS Hot Line that can serve as a way for people to begin to get more information and to find out where to go at the local level. We're now getting over 3,000 calls a day.

But as I suggested a minute ago, the Federal Government is limited in how effective it can be through direct action on its own. It's going to take the combined efforts of governments at all levels working together with business, religious organizations, and a variety of other groups to get the job done.

Because we believe education is so fundamentally important in controlling AIDS, this year the Public Health Service is putting a total of \$296M into information and education programs. That's about 1/3 of our total budget! Of that, about \$30M is going to help the Nation's schools and other private sector national organizations provide AIDS education for our young people. An effort closely linked to education is testing. And that's because when people begin to understand through education that they may have been exposed to the AIDS virus in the past, we need to provide means for them to followup by finding out if they are infected. For several years now the Public Health Service has been funding testing sites through grants to state health departments, and these activities have been increasing substantially in the past year or two. In real terms that means that we've gone from about 9,000 tests and counseling sessions in 1985 to over 500,000 in 1987. And that's just in the publicly funded sites. I believe this is a very encouraging sign. It shows that we CAN get people motivated to find out for themselves on a voluntary basis if they're infected. But we need to make testing even more available than it already is, and to make it more attractive for people to want to get tested.

I'm often asked what I would recommend to a patient about getting tested. Although I believe it's a matter of individual choice, and that a number of factors need to be considered in any individual case, I generally feel that over the past few years there has been more and more reason for an individual to know whether or not they're infected. The first reason is almost purely for reasons of self-interest on the part of the infected person. And that is as we get closer and closer to significant therapeutic drugs, a person should be in a position to know whether they are going to need treatment so that they can begin it at the earliest possible date. Another reason based on self-interest is the fact that it is probably medically helpful for infected people to try to keep themselves in the best possible nutritional status as well as free from as many other infectious diseases as possible. The motivation to do that is a lot greater, it seems to me, if people know they are infected. And thirdly, it makes good sense for a person to know if they're infected in order to take direct steps to protect their sexual contacts from further exposure and to let them know that they may have been exposed. So from both a selfish and a caring point of view, the reasons for getting tested seem compelling to me in the vast majority of cases.

One of CDC's main efforts this year is to get a more accurate picture of the AIDS epidemic. Information of that type comes from antibody studies. And so we've expanded the antibody surveys that were already going on. Now we're getting data on the percentage of people who are infected with the AIDS virus from hospitals in 30 cities, from sexually transmitted disease clinics, drug abuse clinics, from emergency rooms and delivery rooms, from blood collecting agencies and physicians, and from the military. In addition, we hope to be able to

get this same kind of information from selected colleges and universities around the country. In fact, some of those studies are already in progress. Overall, we expect to have many millions of test results this year to give us more facts to work from.

In addition to those surveillance activities, we are in the process of organizing some pilot studies to see if a national random antibody survey is feasible. Here we would test about 50,000 people to establish a firm estimate of the number of people now infected. One of our big concerns is the willingness of people to participate in a random sample --- especially when it involves blood collection and testing by the government. A pilot study to be conducted soon should give us a good idea of how much of a problem this is really going to be.

All of that is going to give us a clearer picture of where we stand at the present time regarding how many people are infected --- not sick with AIDS, but infected with the AIDS virus.

One of the most important things we've learned over the past few years is how significant drug abuse is as a component of AIDS. Whether we like it or not, the fact of the matter is that drug abuse of *ALL* kinds has made and continues to make an already bad situation even worse.

A telling example of this was brought home to me recently when a friend of mine who's an internist told me about a patient of his who had been counselled about the importance of practicing low risk sex so that he would remain seronegative. And he did --- except once every few months when he was under heavy stress. Then he'd get drunk, all the barriers would fall, and he'd get into his old high risk sex habits.

The first few times he was lucky and remained negative for HIV antibodies. But he finally ran out of luck and became infected. My friend, his doctor, was angry, depressed, and just plain frustrated when he talked with me about it because this was not just one isolated case. He's seen several patients --- both men and women --- who are well-informed and well-educated but who have become infected in spite of the best intervention that he could provide.

This points out two things. First, even mild drugs like alcohol can get people into trouble in the sexual transmission of AIDS. And second, information, education, and other more direct intervention strategies are not going to work 100% of the time for everyone, and sooner or later it gets down to the question of an individual's responsibility for him or herself.

But just because there are failures doesn't imply that we should necessarily abandon any of the efforts now in progress. Rather, what we need to do is critically evaluate the effectiveness of what we're doing and focus on those strategies that are proving to be most effective.

In closing I'd like to turn to an issue that we're still trying to resolve.

The neurological complications of HIV infection have added a whole new level of difficulty to AIDS. It's now clear that some HIV infected individuals develop significant neurological problems, and these may be the initial symptoms rather than the classical infectious disease complications such as pneumonias. Because of these findings, questions have been raised about whether there may be early intellectual and motor deficits in some persons infected with HIV but who are otherwise well.



The specific concern that has been raised relates to the ability of such individuals to function responsibly especially in certain occupations which require high levels of intellectual and motor functioning.

The final answers aren't in yet on whether or not a problem actually exists, and if it does what its nature and extent is. But it's an area in which we are trying to develop as much solid data as possible so that the people who are going to have to make policy decisions on this issue in the future will have facts to rely on rather than guesses and opinions. Some of the questions that lie just under the surface and in the background of this issue are whether or not there should be requirements for routine HIV antibody testing in some occupations, and whether seropositive people should then be re-assigned to other less critical positions.

As you can appreciate, the implications of this are extremely broad and serious. And it's always an delicate balancing act to try to temporize while data are being developed to define the problem and to help guide policy, while at the same time being responsive to fundamental concerns about safety.

What started out as a medical and epidemiologic curiosity in 1981 has become a national and global calamity, the dimensions of which we could not even have begun to appreciate in those early days. The future is just as difficult to try to describe because of the extraordinarily complicated interplay of factors that are affecting the AIDS epidemic as we know it today.

But through a national effort combining basic research, drug and vaccine development, and public education, we believe it's going to be possible to stem the tide of infection and to get it under control. It's not going to be easy, and it's not something the Public Health Service or even the entire Federal Government can do alone. Everyone is going to have to carry a share of the responsibility and the burden in fighting this disease. Through the active help of the scientific community, we can begin to get people to see AIDS as the medical problem it truly is and to react to it in the very best sense of what it means to be a human being. It has been said that the ultimate measure of a man is not where he stands in moments of comfort and convenience but where he stand at time of challenge and controversy. There can be no question that AIDS has brought us to a time of scientific challenge and social controversy. If we succeed in our scientific efforts and in our public policies, there is no doubt in my mind that we will have made a major contribution to the physical, mental, and spiritual health of our country.

I can think of no better way to express that concept than to quote what the President said in a speech he gave last year:

"What our citizens must know is this: America faces a disease that is fatal and spreading, and this calls for urgency, not panic. It calls for compassion, not blame. And it calls for understanding, not ignorance. It's also important that America not reject those who have the disease, but care for them with dignity and kindness. This is a battle against disease, not against our fellow Americans." Thank you.



## Seasonal Changes of Indoor Radon in Northern Virginia

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### ABSTRACT

Indoor radon levels in homes located in Fairfax County, Virginia and several other Virginia localities have been measured for three consecutive three-month seasonal intervals using alpha-track detectors. Approximately 50% of the homes had winter indoor radon levels above 4 picoCuries/liter, the EPA's recommended action level. Results from the winter period show that the indoor radon levels were about twice as high as anticipated. For the spring period, indoor radon levels showed a considerable drop with approximately 30% of the homes above 4 pCi/l. Summer values were even lower with approximately 20% of the homes above 4 pCi/l. Indoor radon levels can be correlated with geology, home construction, and seasonal weather.

### INTRODUCTION

There are several natural radioactive decay series. The series beginning with  $^{238}\text{U}$  is the major source of natural radiation exposure to man in the environment. Uranium occurs widely in nature. Locally occurring high levels of uranium are due in large part to geology and chemistry. Specifically, uranium is more soluble in an oxidizing environment and it tends to precipitate in a reducing environment (Levinson, 1980). A significant uranium daughter is  $^{226}\text{Ra}$  ( $t_{1/2} = 1600$  years). Radium is a group II element and consequently follows the chemistry of these elements in the environment. Dissolved in ground water radium is available for chemical reactions that lead to its wide incorporation as insoluble oxides and hydroxides. Radium's daughter,  $^{222}\text{Rn}$ , is the only radioactive inert gas. Radon is widely dispersed in the environment because it is unreactive and it occurs as a gas. The dispersion of a gas that forms in the earth is only limited by the porosity of that soil.

The consequences of exposure to radon and its progeny, notably  $^{218}\text{Po}$  and  $^{214}\text{Po}$  in air are well documented in the literature from studies of uranium miners (George, Hinchliffe, 1972; Mercer, 1975; NIOSH, 1985). Studies in the late 1970's and early 1980's of homes in Colorado and Utah sited on mine tailings showed elevated levels of indoor radon (NCRP, 1984). This enhancement of natural radioactivity resulted from man's interaction with the environment.

The discovery of dangerously high levels of indoor radon in a home in Boyertown, Pennsylvania started a series of studies which revealed how widespread the problem can be (Lafavore, 1986). Evidence is rapidly accumulating which shows that radon is becoming identified as a major form of indoor pollution which leads to an increased risk of developing lung cancer. Radon gas enters the atmosphere by crossing the soil to air interface. It is estimated that the emanation rate is  $0.42 \text{ pCi/m}^2$  per second from soil in the U. S. (NCRP, 1984). Studies have shown that inhalation of these nuclides in the natural environment can result in radiation doses which exceed by far all other doses from natural radiation sources (Cliff and others, 1983; Steinhausler and others, 1983). The EPA policy is that there is no safe level of ionizing radiation (GAO, 1986).

Recently, homes with high levels of indoor radon have been discovered in the northern part of the Appalachian Mountain system (Sextro and others, 1987; Hess and others, 1983; George and Eng, 1983). To determine if elevated indoor radon levels are a problem in the central Appalachians, the Center of Applied Science at George Mason University is conducting an in-depth regional survey in Fairfax County, Virginia and a preliminary survey in several other Virginia localities.

State and County reports in Virginia using measurements of short term duration yielded results that suggested that approximately 10 to 20% of the homes would have indoor radon levels above the 4 picoCuries/liter, (pCi/l), action level of the EPA (VA Dept. of Health, 1987; Fairfax County Health Dept. 1987). Our discovery that in some areas more than 50% of the homes were above this level during the winter season test period generated regional interest among homeowners.

This paper reports on our results for the winter interval, 11/1/86- 1/31/87, the spring interval 2/1/87-4/30/87, and the summer interval 5/1/87-7/30/87 in Fairfax County, Virginia. As a preliminary survey, several measurements have been made in other Virginia localities.

## SETTING

This paper describes the indoor radon situation as it existed in the three geological provinces that comprise the terrane of Fairfax County in northern Virginia. Our study appears to show that several factors related to geology, soil chemistry, home construction, and seasonal weather can combine to produce elevated indoor radon levels.

The indoor radon values are for the winter of 1986-87, the spring of 1987, and the summer of 1987. The number of homeowners participating in this study is continually increasing, and from the start of the study in the fall of 1986, approximately 1500 homes have been entered into the study. Each month about 100 new homes are added, and the present number of participants account for about 0.5% of the total homes in Fairfax County. The goal of the project is to report on 1% of the total homes in Fairfax County. This report reviews the measurements from approximately 390 homes that were measured during the winter interval. These same homes, plus an additional 240 homes were measured during the spring interval, and an additional 500 homes were added for the summer season.



The test series requires the homeowner to participate in the entire four season testing period. Each seasonal radon measurement costs the homeowner \$25.00. Each seasonal exposure interval for the radon monitors was three months. Homes that were accepted into the study were those with a basement, or homes built on a slab. The large number of homes, though self-selected, are thought to be representative of the study area. The homeowners were asked to place the radon monitors in the lowest level of the home. Approximately 90% of the homes had basements, and approximately 90% of these homeowners placed the monitors in their basement. A questionnaire was used to determine the monitor placement, as well as home construction factors and homeowner perception of the the radon situation in Virginia. About 10% of the homes had been tested prior to their inclusion in the present study; the spectrum of pre-study measurements is similar to the results reported in this study.

The homeowner provides an exact location on a Fairfax County map, which when compared to a geological map (Froelich, 1985), made it possible to identify the geologic rock unit underlying the home. The conclusions are based on three-month indoor radon measurements using alpha-track radon monitors provided by Terradex Corporation of Illinois. After the exposure period, the monitors are returned to Terradex for analysis. Terradex develops the film in the monitors, measures the "tracks" produced by the decay of radon progeny near the film surface and calculates the average amount of indoor radon recorded by the film.

## DISCUSSION

The three Appalachian provinces that comprise the terrane of nothern Virginia are the Coastal Plain, the Culpeper Basin of the Triassic Lowland Province, and the Piedmont (Froelich, 1985; Obermier and Langer, 1986). The Coastal Plain Province is located along the eastern edge of the study area. It consists of poorly cemented clastic sedimentary strata, mostly layers of clay and sand, that were deposited during the opening of the modern Atlantic Ocean. These deposits were formed between about 130 million years ago and the present. The western margin of the study area is the Culpeper Basin, which contains terrestrial clastic rocks (siltstone, sandstone, conglomerate) along with extrusive (basalt) and intrusive (diabase) igneous rocks that were all deposited during the Mesozoic Era, about 190-150 million years ago. The Piedmont Province extends from Maryland to Georgia, and rock units of this province underlie most of the central part of the Virginia study area. These rock units are composed of metamorphic and igneous rocks that were formed when the Appalachian Mountains were created during the Paleozoic Era, about 600-300 million years ago.

There are two common methods for measuring indoor radon, the charcoal method and the alpha-track method. The alpha-track method allows passive admission of radon gas into a plastic cup which contains a small strip of film. The alpha disintegrations from the radon produce microscopic tracks on the film. During processing by Terradex, the film is developed with a caustic solution and the tracks are counted. The number of tracks on the film is correlated



TABLE 1. Indoor Radon Level in the Piedmont, Culpeper Basin and Coastal Plain Provinces of Virginia for 11/1/86 to 1/31/8

Rock Unit	Median Radon pCi/l	% Homes Above 4 pCi/l	% Homes Above 10 pCi/l	Homes Tested	% From Basements
Piedmont					
Phyllite	4.7	62	7	32	93
Metabasalt	4.4	80	10	18	100
Gneiss	3.5	39	6	87	86
Schist	4.8	63	17	141	91
Granitoid Rocks	2.9	25	0	36	78
Culpeper Basin					
Diabase-Hornfels	3.8	40	0	10	90
Sedimentary Rocks	2.7	32	4	28	79
Coastal Plain					
Sedimentary Strata	2.4	14	3	38	77
All Homes	3.7	44	11	329	86
Basement only	3.9	47	9	272	

with radon concentration in the air utilizing a conversion factor derived by a calibration facility (EPA, 1986).

Alpha-track detectors have several advantages over charcoal adsorption. Both detectors are low in cost, but the alpha-track detectors are not sensitive to temperature or humidity changes and are not limited to short term measurements. An early part of our study showed that measurements by the activated charcoal method vary considerably from those of the alpha-track method, probably because the indoor radon level varies considerably over short time intervals (Mose and Mushrush, 1987). Based on this observation, and the assumption that the longer test interval provides a closer estimate of the average yearly radiation dose rate, the present study reports only data obtained by the alpha-track method over 90-day measuring intervals.

Terradex claims a  $\pm 10\%$  accuracy at 4 pCi/l for a 30-day exposure. The actual uncertainty depends primarily on the measurement interval and the amount of radon in the exposure room. Based on a detailed study currently in progress, our estimate for the accuracy of the 90-day exposure used in this study is  $\pm 30\%$  at the 95% confidence level. We find no evidence that the inaccuracies yield measurements that are mostly too low or mostly too high. These considerations lead us to believe that individual homeowners may have obtained some measurements that were higher or lower than their actual radon concentrations, and for that reason we advise homeowners to contemplate remedial work only after measuring indoor radon over several seasons. The random nature of the possible inaccuracies lead us to believe that the compilations obtained for large groups of homes such as are presented later in this paper are

TABLE 2. Indoor Radon for the Piedmont, Culpeper Basin, and the Coastal Plain Provinces of Virginia for 2/1/87 to 4/30/87.

Rock Unit	Median Radon pCi/l	% Homes Above 4 pCi/l	% Homes Above 10 pCi/l	Homes Tested	% From Basement
Piedmont					
Phyllite	3.2	39	5	64	86
Metabasalt	3.1	25	0	8	100
Gneiss	2.5	25	4	122	88
Schist	4.1	45	10	171	87
Granitoid Rocks	2.2	23	2	62	81
Culpeper Basin					
Diabase & Hornfels	2.4	7	0	18	83
Sedimentary Rocks	2.3	21	5	56	73
Coastal Plain					
Sedimentary Strata	1.7	11	0	63	73
All Homes	2.7	30	5	573	83
Basement only	2.9	32	6	457	

reasonably correct. We are encouraged in this belief by noting that when the geology, weather and home construction in the contiguous counties of Virginia (Loudoun and Prince William) in this report are studied separately, their radon characteristics are similar.

Radon poses a problem indoors due to confinement of a gas within the small volume of air inside buildings and homes. Significant exposures result, since people tend to spend 80% of their time indoors (NCRP, 1984). The results of the winter testing interval indicated that the indoor radon levels were about twice as high as anticipated (Alter and Oswald, 1987). Table 1 shows that the median radon value in the Coastal Plain province was 2.4 pCi/l, the Culpeper Basin was 3.8 and 2.7 pCi/l for diabase and sedimentary rocks respectively, and the Piedmont gave the greatest variation from 2.9 pCi/l for granitoid rocks to 4.8 pCi/l for schist. For Fairfax County, 44% of the homes were above 4 pCi/l and 11% were above 10 pCi/l.

The results for the spring testing interval are given in Table 2.

The median indoor radon value in the Coastal Plain province was 1.7 pCi/l, the Culpeper Basin was 2.4 and 2.3 pCi/l for diabase and sedimentary rocks respectively, and for the Piedmont province the value ranged from a low of 2.2 pCi/l for granitoid rocks to a high of 4.1 pCi/l for schist. Approximately 30% of the homes had indoor radon levels above 4 pCi/l and 5% of the homes had levels above 10 pCi/l.

The results for the summer test period were anticipated to be the lowest of these three seasons. Table 3 shows that indeed the levels of indoor radon were equal to or lower than the spring values for all three provinces. Homes are con-

TABLE 3. Indoor Radon for the Piedmont, Culpeper Basin, and the Coastal Plain Provinces of Virginia for 5/1/87 to 7/30/87

Rock Unit	Median Radon pCi/l	% Homes Above 4pCi/l	% Homes Above 10pCi/l	Homes Tested	% From Basement
<b>Piedmont</b>					
Phyllite	2.8	27	3	101	87
Metabasalt	1.4	23	0	13	100
Gneiss	2.3	14	0	228	81
Schist	3.1	34		228	85
Granitoid Rocks	2.0	12	2	106	82
<b>Culpeper Basin</b>					
Diabase & Hornfels	1.5	0	0	30	77
Sedimentary	1.3	10	3	67	73
<b>Coastal Plain</b>					
Sedimentary Strata	1.6	5	1	112	83
All Homes	2.3	20	2	911	82
Basement only	2.4	20	2	713	

TABLE 4. A Comparison Of Basement Wall Construction With Basement Radon Concentration In Fairfax County

Basements	Median Rn in pCi/l	% Over 4 pCi/l	% Over 10 pCi/l	Number of Homes
<b>Concrete Block Walls</b>				
Winter	3.9	54	1	172
Spring	3.0	34	6	304
Summer	2.5	21	1	471
<b>Poured Concrete Walls</b>				
Winter	3.4	41	7	91
Spring	2.7	27	6	152
Summer	2.3	19	2	240

tinually added to the survey, so the seasonal intervals in Tables 2 and 3 reflect a different number of total homes.

The median indoor radon value in the Coastal Plain province was 1.6 pCi/l, the Culpeper Basin was 1.5 and 1.3 pCi/l for diabase and sedimentary rocks respectively, and the Piedmont gave the greatest variation from 1.4 pCi/l to 3.1



pCi/l for the metabasalt and the schist rock units respectively. Fairfax County showed 20% of the homes exceeding the 4 pCi/l level and 2% exceeding the 10 pCi/l level. Overall, the winter season indoor radon levels are considerably higher than those for the spring season, and the summer period show the lowest values. We believe that these lowered spring and summer values probably result from increased ventilation (open windows, etc).

Both the northeast United States and the western mountain state regions show elevated levels of indoor radon and it has been noted that both regions contain granitic mountain ranges (Alter and Oswald, 1987; Tanner, 1986). In Sweden, certain localities have been classified as having high radon potential based on the presence of granite (Tanner, 1986). It is interesting to note that in the present study, the phyllite and schist rock units in the Piedmont Province showed the highest values for indoor radon. Homes over the granitic rocks show lower median radon for all three seasonal test periods, and these homes over the granitic rocks also show a lower percentage of homes above the 4 pCi/l level.

This apparent contradiction concerning the indoor radon potential for granitic rocks is resolved by understanding the effect of recrystallization on granite. In general, granitic rock is often enriched in uranium over its host rock when it is first emplaced and crystallized. Homes over a soil derived from such undeformed granite, commonly found in portions of most major mountain systems, would tend to have an indoor radon problem. However, in the counties examined in the present study, most of the granite was recrystallized during post-emplacement deformation associated with mountain building. The recrystallization process tends to displace uranium to the surface of minerals as they reform during such rock deformation, and the uranium is then easily removed by the passage of intergranular water (Speer and others, 1981). As a consequence of this process, uranium diffuses into the host rock of the granite such as the gneiss in the present study, or into more distant rock units such as the phyllite or schist. Thus in terranes such as the present study area, granitic rock is an indicator of a potential indoor problem, but not a rock type that can be used to precisely locate homes with a potential radon problem unless the granite was emplaced after the rock deformation associated with mountain building.

The observed elevated indoor radon levels can also be attributed to variables other than rock type and weather. Some component of the variation can be associated with home construction. A preliminary data base (Alter and Oswald, 1987) on the nation-wide distribution of indoor radon shows a correlation between basement and non-basement radon statistics. Other studies (Prichard and others, 1982; Cohen, 1985; Henschel and Scott, 1986) have also shown a correlation with home structure. However, these data summaries are mostly either over very large areas, such as an entire state with a random selection of homes, or for a relatively small area, such as a single small group of homes.

The results of our study of approximately 1000 homes also shows that indoor radon can be correlated with home construction. Table 4 presents a comparison between indoor radon and basement wall construction for all three seasons. The results also show that indoor radon values were higher for the winter season in basements where the walls are composed of concrete blocks. For the winter period 54% of these rooms exceeded the 4 pCi/l value, 34% of the rooms exceeded this value for the spring period, and 21% of the rooms for

TABLE 5. Comparison Of First Floor Radon And Basement Wall Construction In Fairfax County.

Floor is Above	Median Rn in pCi/l	% Over 4 pCi/l	% Over 10 pCi/l	Number of Homes
Concrete Block Walls				
Winter	3.1	29	14	14
Spring	2.4	21	3	29
Summer	2.2	17	1	59
No Basement-Slab Home				
Winter	2.5	22	6	19
Spring	1.4	11	0	35
Summer	1.3	7	0	59
Poured Concrete Walls				
Winter	1.8	0	0	6
Spring	1.3	9	9	11
Summer	1.5	0	0	15

the summer period. In homes in which the radon concentration was measured in basements where the walls are composed of poured concrete, the indoor radon concentration was above the 4 pCi/l level in only 41% of the basements during the winter period, 27% during the spring and 19% during the summer period. Presumably, the greater radon concentrations found in basements with concrete block walls compared to poured concrete walls is due to the tendency for concrete block walls to crack. Radon enters the home primarily from soil immediately adjacent to floors and walls. The results show that while geology and weather both play a major role in the observed indoor radon values, the composition of basement walls is also a contributing factor.

Table 5 shows a relationship between the indoor radon values on the first floor and the composition of basement walls.

For all three seasons, the first floor radon value observed for homes in Fairfax County were always highest above concrete block wall basements, and lowest above poured concrete wall basements.

A comparison of Tables 4 and 5 shows that the first floor radon above a concrete block basement is about 80% of the basement level, and first floor radon above a poured concrete basement is only 60% of the basement level. Apparently, a small reduction in basement radon has a significant effect on first floor radon.

Table 6 shows the indoor radon levels for the contiguous Loudoun and Prince William Counties and for various other localities in Virginia.

Data sets with less than 10 homes probably represent an insufficient size for statistical analysis. Both Loudoun and Prince William show the same trends as Fairfax in terms of the seasonal variation of the indoor radon level, and the percentage of homes over 4 pCi/l. Even for the counties where the sample homes

TABLE 6. Indoor Radon in Other Localities in Virginia

Virginia County	Number of Homes	Season	Median Radon	% Over 4 pCi/l	% Over 10 pCi/l	Maximum Radon
Clarke	2	Winter	9.6	100	50	10.2
	2	Spring	8.3	100	0	9.1
	2	Summer	5.6	100	0	7.0
Fauquier	2	Winter	3.3	0	0	3.3
	2	Spring	1.6	0	0	3.2
	2	Summer	3.2	0	0	3.9
Richmond City	2	Winter	5.6	100	0	6.1
	7	Spring	1.9	14	0	7.0
	7	Summer	1.3	29	0	5.0
Loudoun	18	Winter	4.3	56	22	20.8
	24	Spring	3.0	38	21	16.2
	30	Summer	2.3	23	7	15.8
Prince William	14	Winter	3.8	50	0	8.5
	18	Spring	2.8	22	6	11.2
	33	Summer	2.3	12	0	6.9

are small in number, the decrease in median radon fits the expected seasonal variation.

### CONCLUSIONS

The problem of indoor radon and its progeny has been well documented. Many studies of the indoor radon problem have concentrated on large geographical areas with a random selection of test sites. The present study, to overcome the randomness of widely varied measurements, concentrated on achieving results from about 1000 homes in Fairfax County, Virginia. Observed radon values in the present study can be correlated with the geology, the season, and home construction. The Piedmont Province (particularly the schist rock unit) gave the highest median indoor radon values, 4.8 pCi/l for the winter period, 4.1 pCi/l for the spring season and 3.1 pCi/l for the summer season. Homes in the Culpeper Basin gave generally lower median radon values, and the Coastal Plain homes gave the lowest median indoor radon. Winter measurements were higher than either spring or summer values due to the decreased influx of outside air in the colder season. Construction variables are less well studied, but it is now clear that basements with cinder block walls tend to have higher radon concentrations than basements with poured concrete walls, presumably because cinder block is more likely to be permeable and to develop



fractures. A combination of factors can be used to develop a description of the worst-case situation: a winter measurement in the cinder block basement of a home built over the schist rock unit of the Piedmont Province. In a similar fashion, a situation of lowest indoor radon can also be described: a summer measurement in an above ground level room of a home built over the sedimentary strata of the Coastal Plain Province. About 70% of the homes with the worst-case combination of factors were above 4 pCi/l. Less than 10% of the homes with the factors that are associated with reduced radon concentration were above 4 pCi/l. It is obvious that with some care, a potential homeowner can select a home with geology and construction compatible with low indoor radon concentration. It is also obvious that the owners of presently occupied homes can be alerted to a potential indoor radon problem if the effects of geology and home construction are reasonably well understood.

#### LITERATURE CITED

- Alter, H. W., and R. A. Oswald. 1987. Nationwide Distribution of Indoor Radon Measurements, A Preliminary Data Base. *APCA Journal* 37: 227-331.
- Cliff, K. D., A. D. Dixon, M. R. Green, and J. C. H. Miles. 1983. Radon Daughter Exposure in the U. K. *Health Phys.* 45:323-330.
- Cohen, B. L. 1985. Surveys of One Year Average Rn Levels in Pittsburgh Area Homes. *Health Phys.* 49:1053-1059.
- EPA (U.S. Environmental Protection Agency). 1986. Interim Indoor Radon and Radon Decay Product Measurement Protocols. EPA 520/1-86-04. 60 pp.
- Fairfax County Interim Radon Report. 1987. Fairfax County Health Department, Fairfax, VA, 20 pp.
- Fleischer, R. L., A. Moro-Campero and L. G. Turner. 1983. Indoor Radon Levels in the Northeastern U. S., Effects of Energy Efficiency in Homes. *Health Phys.* 45:407-412.
- Froelich, A. J. 1985. Folio of Geologic and Hydrologic Maps for Land Use Planning in the Coastal Plain of Fairfax County and Vicinity, Virginia. U. S. Geological Survey Miscellaneous Investigations Series Map I-1423.
- GAO (U. S. General Accounting Office) 1986. Air Pollution: Hazards of Indoor Radon Could Pose a National Health Problem. Report to the Pennsylvania Congressional Delegation, House of Representatives. GAO/RCED-86-170
- George A. C., and L. E. Hinchliffe. 1987. Measurements of Radon Concentration in Residential Buildings: Radon and Its Origins. Hopke, R. K., ed., ACS Symposium Series 331, pp. 42-62.
- George A. C., and J. Eng. 1983. Indoor Radon Measurements in New Jersey, New York and Pennsylvania. *Health Phys.* 45:397-400.
- George, A. C., and L. Hinchliffe. 1972. Measurement of Uncombined Radon Daughters in Uranium Mines. *Health Phys.* 23:791-803.
- Henschel B. D., and A. G. Scott. 1986. The EPA Program to Demonstrate Mitigation Measures for Indoor Radon. Proceedings of the APCA Indoor Radon Conference, APCA. Pittsburgh, PA SP-54, pp. 110-121.

- Hess, C. T., C. V. Weiffenbach and S. A. Norton. 1983. Environmental Radon and Cancer Correlations in Maine. *Health Phys.* 45:339-348.
- Lafavore, M. 1986. The Radon Report. Rodale's New Shelter. January 1986. pp. 29-35.
- Levinson, A. A. 1980. Introduction to Exploration Geochemistry. Wilmette, Illinois: Applied Publishing Ltd. 924 pp.
- Mercer, T. T. 1975. Unattached Radon Decay Products in Mine Air. *Health Phys.* 28:158-161.
- Mose D. G., and Mushrush, G. W. 1987. Regional Levels of Radon in Virginia and Maryland. American Chemical Society Annual Meeting Abstracts, paper Environ. 64
- National Institute for Occupational Safety and Health. Evaluation of Epidemiologic Studies Examining the Lung Cancer Mortality of Underground Miners. Cincinnati. May 9, 1985, 80 pp.
- NCRP (National Council on Radiation Protection and Measurements). 1984. Exposures from the Uranium Series with Emphasis on Radon and its Daughters. NCRP Report No. 77. 131 pp.
- Nero, A. V. 1983. Indoor Radiation Exposures from  $^{222}\text{Rn}$  and its Daughters: A View of the Issue. *Health Phys.* 45:273-282.
- Nero, A. V., M. L. Boegel, C. D. Hollowell, J. G. Ingersoll and W. W. Nazaroff. 1983. Radon Concentration and infiltration Rates Measured in Conventional and Energy Efficient Houses. *Health Phys.* 45:401-405.
- Obermeier, S. F., and W. H. Langer. 1986. Relationships Between Geology and Engineering Characteristics of Solid and Weathered Rocks of Fairfax County and Vicinity, Virginia. U. S. Geological Survey Professional paper 1344.
- Prichard, H. M., F. F. Gesell and C. F. Hess. 1982. Associations Between Grab Samples and Integrated Radon Measurements in Dwellings in Maine and Texas. *Environ. Int.* 8:83-89.
- Saccomano, G., V., E. Archer, and O. Auerbach. 1981. Age Factor in Histological Type of Lung Cancer Among Uranium Miners. A Preliminary Report in Radiation Hazards in Mining. M. Gomez, ed., Golden, CO, pp. 675-679.
- Sextro R.G., B. A. Moed, W. W. Nazaroff, K. L. Revzan and A. V. Nero. 1987. Investigations of Soil as a Source of Indoor Radon: Radon and its Origins. Hopke, P. K., ed., ACS Symposium Series 331, pp. 10-29.
- Speer, J. A., T. N. Solberg, and S. W. Becker. 1981. Petrography of the Uranium-Bearing Minerals of the Liberty Hill Pluton, South Carolina: Phase Assemblages and Migration of Uranium in Granitoid Rocks. *Economic Geology* 76:2162-2175.
- Steinhausler, F.W., W. Hoffman, E. Pohl, and J. Pohl-Ruling. 1983. Radiation Exposure of the Respiratory Tract and Associated Carcinogenic Risk Due to Inhaled Radon Daughters. *Health Phys.* 45:331-337.
- Tanner, A. B. 1986. Geological Factors that Influence Radon Availability. in Indoor Radon. Proceedings of an APCA International Specialty Conference. Air Pollution Control Association. pp. 1-12.
- Virginia Department of Health Radon Survey. 1987. Virginia Bureau of Radiological Health. Richmond, VA. 18 pp.

## A Preliminary Study of Calcium Kinetics During Acute Stress in Divergent Life Forms

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### ABSTRACT

These experiments question if the profile of responses to acute stress in phylogenetically distant species (laboratory rats and *Pomoxis nigromaculatus*) include a change in blood calcium levels. Fish were exposed to thermal stress for 30 minutes or less, with blood samples taken after they were returned to normal conditions for 25 minutes.. Serum calcium increased in all stressed fish, regardless of sex or maturity, but highest values were in mature females. In rats, serum calcium levels were determined before and after a stress period of 1.5 hours in parathyroidectomized (PX) males (160-200g), in sham-operated controls, and in PX rats injected with 10, 20 or 30 USP units of parathyroid hormone (PTH) per 100g body weight. Calcium levels in intact sham-operated rats and the PX + 30PTH group increased significantly in response to stress. Levels in stressed uninjected PX rats and in those injected with 10 USP PTH dropped by 7.7% and 14.7% respectively; in the PX + 20PTH group the drop was only 3.3%. There was a calcium flux response to short-term stress in both taxa, and a role for PTH in effecting this response in the mammal.

### INTRODUCTION

It is well established that long-term stress in fishes, and in man and other mammals, results in elevated blood calcium levels (*inter alia*, Bergstrom, 1978; Campana, 1983; Houston and Koss, 1984; Wiener et al., 1985; Bourne, 1986). On the other hand, very little is known about the effects of short-term stress on calcium flux in any species. The objective of the present preliminary study was to examine the possibility of such short-term effects and to compare two phylogenetically distant species, the black crappie, *Pomoxis nigromaculatus*, a freshwater fish, and the laboratory rat.



## METHODS AND MATERIALS

**EXPERIMENTS IN FISH.** Animals were collected from Lake Anna, Louisa County, Virginia, in early Spring, by direct-current electrofishing and were transported to the laboratory in a battery aerated, 115 liter, styrofoam cooler, where they were kept in tap water in a 1135 liter storage tank, filtered by three Dynaflo 150 pumps, for at least a week before experimentation, to allow for acclimatization. They were fed goldfish (from a local pet store) and cyprinid minnows seined from nearby tributaries of the James River. Temperature (17-20 C) and pH (7.8-8.1) of the tank water were closely monitored. Fungal and bacterial infections were controlled by adding methylene blue (5% solution, 1 drop/gal water) and formalin (15% solution, 1 drop/gal water) to the tank.

The design for the first experiment was as follows. Two 115 liter tanks were set up in the same room that contained the storage tank. Chemically dechlorinated water (Genesis, Aquarium Products) of the same pH as the storage tank water was added and equilibrated to ambient temperature. A charcoal filter and air stone were used for filtration. Fish selected at random from the storage tank were transferred either to a control or an experimental tank and allowed to acclimate to the new tank for 24 hours. After acclimation, approximately 75 liters of water were siphoned from each tank until the dorsal fins of the fish were above the surface of the water. Twenty gallons of fresh, dechlorinated water of the acclimated temperature were added to the control tank; 75 liters of water 10 °C colder were added to the experimental tank. Thirty minutes later, fish were removed from each tank, a ventral incision was made exposing the heart, and blood was collected into a 1 ml tuberculin syringe from the ventral aorta, transferred to a plastic test tube (Kimball, 12 x 75 ml) and refrigerated for 1 hour. Sex was noted. Gonads were removed and weighed, and percent body weights calculated.

The design for the second experiment was the same as for the first except that (1) a third experimental tank was added containing water 10 °C warmer than acclimated temperature, and (2) fish were exposed to either cold or hot water for only 5 minutes (cold-shock, hot-shock), after which they were kept in water of the acclimated temperature for 25 minutes when blood was drawn and other data collected as described above.

**EXPERIMENTS IN RATS.** Sprague-Dawley male rats, purchased from Dominion Laboratories, Dublin, Va. were housed two to a cage in a photoperiod of 12L:12D and were given Purina Lab Chow and tapwater *ad libitum*. At the time of experimentation they weighed 160-200g.

The rats were divided into five groups: sham-operated, parathyroidectomized (PX), PX + 10 USP units parathyroid hormone (PTH), PX + 20 USP units PTH and PX + 30 USP units PTH. A replacement dose of PTH at 10 USP units/100 grams of body weight (BW) was found adequate, in preliminary trials, to restore blood calcium to normal levels in PX rats during a 6 to 10-hour period after injection.

Parathyroidectomy was done by cautery and the intact rats underwent surgery identical to that of parathyroidectomy except that only connective tissue near the thyroid gland was cauterized (sham-operated group). In both cases sodium pentobarbital (30 mg/Kg BW) was used for anesthesia. PTH (Sigma,

P0892) was dissolved in distilled water to give a concentration of 20 USP units per 0.1 ml. Fifteen to twenty hours after surgery, PX rats were injected subcutaneously with 10, 20 or 30 USP units of PTH/100 gram BW and the sham-operated rats were injected with PTH vehicle. Six hours after the injection, the stress experiments were begun. Each rat was lightly anesthetized with ether and placed in a body-tight plexiglas container that restricted movement. A blood sample was taken immediately, from the tail, by cut-down. After sampling, while still held in the plexiglas container, rats were subjected to 1.5 hours of noise stress. After the 1.5 hours of combined confinement and noise stress, the rats were again slightly etherized to permit unhindered blood flow, and blood was obtained as before. The source of the noise stress was a commercial device, ULTRASON, emitting Ultra High Frequency sound (UHF, 112 db @ 3 ft. @ 21 Kc), designed by the manufacturer as a rat eradicator (Rat-X, Chicago). In addition to these tests a control experiment with a sham group and a PX + 10PTH group was used to test for stress that occurred during blood sampling *per se* (three animals/group). Blood samples were taken as described above and then animals were placed without confinement in a quiet location for the standard 1.5-hour period after which blood was again taken for calcium analysis.

Time intervals for applied stress were chosen on the basis of pilot experiments done with three rats and four fish. In both fish and rats, serum was obtained, after clotting, by centrifugation. Total calcium levels were determined colorimetrically with a calcium diagnostic kit (Sigma, 585-A/586). Individual runs, conducted over a period of several weeks, always involved representatives of both control and experimental groups.

Differences in serum calcium levels were analyzed using Bartlett's Homogeneity Test (Zar, 1974). Results were parametric and differences between means were tested for significance with Student's *t* test and analysis of variance. Data were analyzed for whole populations and, in fish separately according to sex, and were correlated using the Spearman Rank Test (Zar, 1974).

## RESULTS

The results are shown in Figures 1-3. Fish subjected either to cold water for 30 minutes, or to cold-shock or hot-shock for 5 minutes, showed mean serum calcium levels that were respectively 23% (Fig. 1A), and, 23% and 26.5% above control levels (Fig. 1B).

Serum calcium values for the stressed groups from both experiments were not significantly different from each other, allowing the values for the stressed groups in both experiments to be combined and rearranged according to sex (Fig. 2). Similarly, the data for unstressed control males and females, mature or immature, showed no differences and were therefore pooled, as were data for stressed mature and immature males. Data for stressed females, however, showed differences between mature and immature fish and are reported individually. Data on six fish were not included because of gonadal ambiguity; two were control fish and four were stressed immature fish. Stressed mature females exhibited 8.3% higher serum calcium than stressed males or stressed immature females but there was no difference in serum calcium levels between stressed males and stressed immature females.

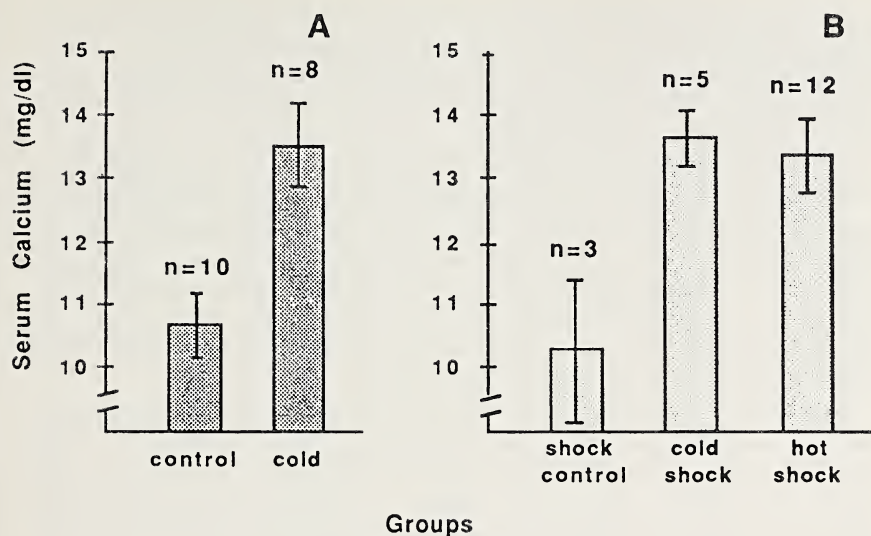


FIGURE 1. Comparisons of serum calcium levels in unstressed fish with those in fish subjected to thermal stress. A. Experimental group (30 min cold) vs. controls,  $p < 0.025$ . B. Experimental groups, 5 min cold shock/hot shock vs. controls,  $p < 0.025$  and  $p < 0.01$ , respectively.

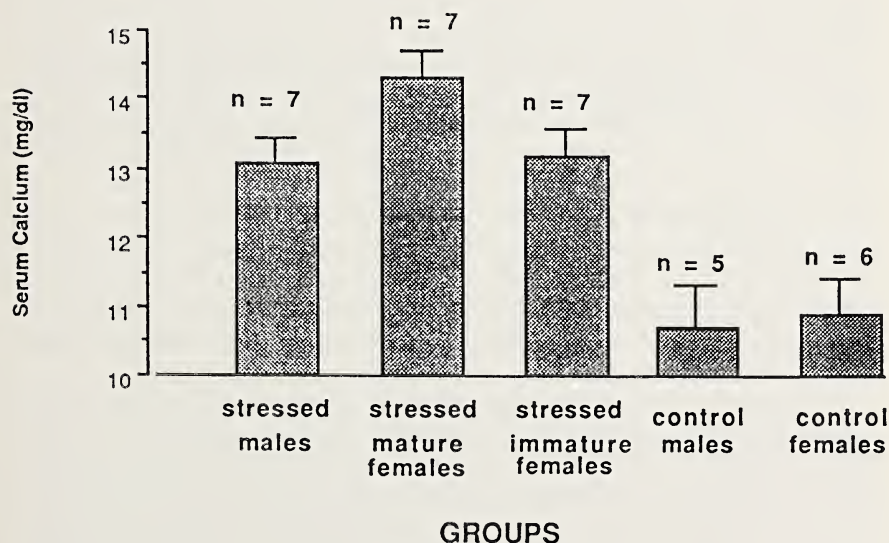


FIGURE 2. Comparisons of serum calcium levels by sex in unstressed fish with those in fish subjected to thermal stress. Stressed groups vs. unstressed males and females,  $p < 0.001$ ; stressed males vs. stressed immature females, no difference  $p < 0.05$ ; stressed mature females vs. stressed males or stressed immature females,  $p < 0.025$ .



As in fish, serum calcium in the control, intact sham-operated rats also increased with stress, but to a lesser degree (approximately 7%, Fig. 3). A comparable rise in response to stress (5.2%) only occurred in the PX group given 30 USP units of PTH. Statistical analysis showed no significant difference between these two groups ( $p > 0.05$ ).

Parathyroidectomy produced the expected decrease in serum calcium, but after stress, serum calcium levels dropped even further. Ten units of USP PTH were sufficient to return calcium levels to normal in unstressed PX rats but neither 10 nor 20 USP units PTH were sufficient to permit the rise in serum calcium with stress that was seen in the control and 30 USP PTH groups. However, in contrast to PX + 10PTH, serum calcium levels of the PX + 20PTH rats dropped only 3.3% from their unstressed levels, considerably less than the 14.7% decrease in calcium levels in the PX + 10 group.

Values for the sham-operated and PX + 10PTH groups that were used to test for a possible calcium mobilization response to blood sampling alone were not different from each other at either 0-time ( $7.81 \pm .01$  vs  $7.83 \pm .02$ ,  $p > 0.01$ ) or 1.5 hours later ( $7.80 \pm .02$  vs  $7.81 \pm .01$ ,  $p > 0.01$ ) nor were they statistically different from before-stress values in identical groups of rats that were subsequently subjected to 1.5 hours confinement/UHF stress.

## DISCUSSION

These findings clearly demonstrate that in diverse life forms represented by laboratory rats and freshwater fish part of the response to short-term stress in the intact animal is a rise in serum calcium.

The influence of sex or maturity on this calcium flux response was not examined in the rat, but in fish our data show maximum sensitivity in the mature female with no apparent differences among mature males, immature males, and immature females. It is well-known that under ordinary conditions both freshwater and sea water mature females exhibit higher blood calcium levels than do males or immature fish (Miescher, 1897; Hess *et al.*, 1928; van Someren, 1937). It should be noted, however, in the experiments reported here, values for mature female controls were not different from other controls. We have no explanation for this but it is the basis for our interpretation that our findings show greater sensitivity in the mature female, with starting levels not already having been elevated.

In rats, the response is mediated by PTH. Stressed rats without parathyroid glands exhibited a marked decrease in serum calcium in contrast to the rise in sham-operated rats, indicating an absolute requirement for the parathyroid glands for this response. This strongly suggests that an initial, classical (Patt and Luckhardt, 1942) hypocalcemic signal resulting in PTH release was operative in the intact rat. This interpretation is further substantiated by the PX + 10PTH data. The PX + 10PTH rats had before-stress calcium levels similar to the unstressed sham-operated rats but, in contrast to the shams, and, in keeping with the stress response in PX rats, the PX + 10PTH rats exhibited a lesser but still significant stress-induced drop in serum calcium. It would appear that whereas the unstressed PX + 10PTH rats had enough PTH available to bring their low serum calcium levels back toward normal, no response to a hypocalcemic signal was possible in the absence of parathyroid tissue, and the PTH replacement

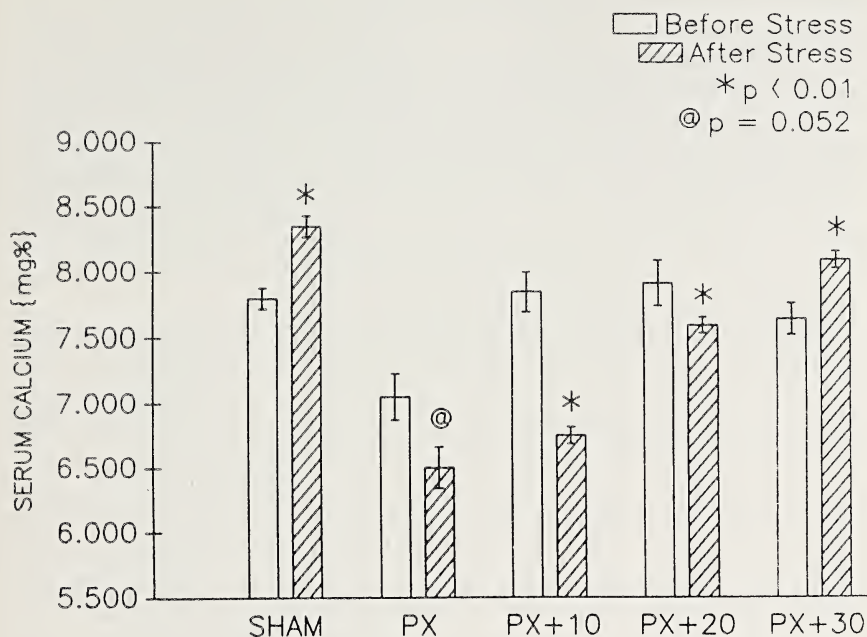


FIGURE 3. Changes in serum calcium levels in response to short-term stress in rats that were sham-operated, parathyroidectomized (PX), or PX and treated with various amounts of PTH (units/100 g BW). Note the 14.7% drop in serum calcium in the PX+10 group compared to the 5.2% increase in the PX+30 group and the 7.0% increase in the sham-operated group. Plain bars = before stress; Striped bars = after stress. The brackets indicate the standard error of mean for the samples. Statistical  $p$  values compare each member of a pair of data with one another. Shams,  $n=12$ ; PX,  $n=8$ ; PX+10,  $n=8$ ; PX+20,  $n=6$ ; PX+30,  $n=10$ .

dose was simply too small to provide sufficient reserve. That this reserve could be supplied exogenously is evident from the data on PX+20PTH and PX+30PTH rats. In contrast to PX or PX+10PTH groups, stressed PX+20PTH rats exhibited only a marginal decrease in serum calcium levels whereas the PX+30PTH animals responded to the burden imposed by stress exactly as did the intact rat, *i.e.* with a rise in serum calcium. Also, note the fact that the different dose-related responses among PX+10, PX+20 and PX+30 rats occurred in the face of identical PTH-replacement starting values for blood calcium, adding further credence to our interpretation of mediation by the availability of increased amounts of hormone released in response to an early hypocalcemic signal in the intact rat.

If it is true that an increase in PTH release in response to hypocalcemia is a part of the mechanism that prevails in the overall increase in blood calcium seen after 1.5 hours of stress, as our findings suggest, what other mechanisms also might be involved 1) in the initial hypocalcemia, and 2) in an eventual physiological return to stabilization? For example, how does one explain the apparent over-ride that we observed, to higher than resting "normal" values? It would seem logical to suspect that such apparent over-ride at 1.5 hours is simply an expression of the second phase of an alarm shock/counter shock (Selye, 1946)



triphasic response that would lead eventually to stabilization once the stress stimulus is removed. Also, glucocorticoids might be involved in the mediation of such stabilization (with time) by way of their ability to act directly on bone to sensitize it to the actions of PTH and thus decrease the need for increased amounts of that hormone (Chen and Feldman, 1978, 1979; Hahn and Halstead, 1979; Liskova-Kiar, 1979; Ng et al., 1979; Korkor *et al.*, 1983; Rodan et al., 1984; Zajac, *et al.*, 1986). With regard to the question of the initial, stress-induced hypocalcemic signal, the answer may be much more difficult to find. One may speculate that it is calcitonin released in response to stress catecholamines, but this is complicated by the evidence that both calcitonin and PTH can be released by betaadrenergic stimulation (Aurbach *et al.*, 1981).

Although we are unaware of any published data on rats with which we might compare our own, there is other, recent information, albeit conflicting, for fish. Ruben and Bennett, (1981), working with rainbow trout, reported a finding similar to ours, namely a rise in total serum calcium ( $\text{Ca}_t$ ) in rapid response to short-term stress, in this case, forced-intense-activity stress. Martem'yanov and Zaprudnova (1982) reported decreasing calcium ion ( $\text{Ca}^{+2}$ ) values in two different species of cyprinids and in specimens of northern pike, during a 10-30 minute period of post-capture stress. Andreassen (1985) repeated the Ruben and Bennett experiment but measured both  $\text{Ca}_t$  and  $\text{Ca}^{+2}$ . The results showed no difference in  $\text{Ca}_t$  but a rise in  $\text{Ca}^{+2}$ . Thus, it would appear that whether  $\text{Ca}_t$  or  $\text{Ca}^{+2}$ , or both, were measured, previous data are completely at odds. Our results support Ruben and Bennett's original findings. It should be noted, however, that the controversy may reside in the possibility of very rapid compensatory changes in response to a starting decrease in serum levels discussed above for the rat.

With regard to the question of hormonal control, it seems clear in the rat that parathyroid hormone (PTH) is involved in the rapid rise in calcium with acute stress, and that this part of response might be mediated by rapid catecholamine-induced release of PTH. In fish, however, resolution of this question may be much more difficult. Both mammalian PTH and an immunological PTH-like material from fish Corpuscles of Stannius (Lopez, *et al.*, 1981; Tisserand-Jochem *et al.*, 1987) are hypocalcemic in fish, not hypercalcemic (Wendelaar Bonga *et al.*, 1986). On the other hand, a PTH-like factor found in fish pituitary glands is hypercalcemic (Parsons *et al.*, 1978) as is the much-studied, but relatively slow acting pituitary hormone, prolactin (Pang, 1973; Pang and Pang, 1986). Whether a fast-acting catecholamine might be the prime candidate (Mazeaud and Mazeaud, 1981) for at least the initial stimulus to the observed rapid rise in calcium in fish, other participants in the cascade of stimulus-response coupling thus remain only putative. The key may lie in the possibility that the ultimate target for moving calcium into the blood is the chloride cell of the fish gill epithelium (Payan et al., 1981; Wendelaar Bonga *et al.*, 1984).

It will be necessary to examine the questions our findings raise and the possibilities we propose, beginning with a careful time-course study that describes what changes actually occur and when they occur over the short term. Our findings point clearly to the need for such studies and to the existence of a new dimension in calcium homeostasis.



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# LITERATURE CITED

- Andreasen, P. 1985. Free and total calcium concentrations in the blood of rainbow trout, *Salmo gairdneri*, during 'stress' conditions. J. Exp. Biol. 118:111-120.
- Aurbach, G.D., S.J. Marx and A.M. Spiegel. 1981. Parathyroid hormone, calcitonin and the calciferols. In: Textbook of Endocrinology (R.H. Williams, ed.):922-1031.
- Bergstrom, W.H. 1978. Hypercalciuria and hypercalcemia complicating immobilization. Am. J. Dis. Child. 132-553.
- Bourne, P.K. 1986. Changes in haematological parameters associated with capture and captivity of the marine teleost, *Pleuronectes platessa* L. Comp. Biochem. Physiol. 85A:435-443.
- Campana, S.E. 1983. Calcium deposition and otolith check formation during periods of stress in Coho salmon, *Oncorhynchus kisutch*. Comp. Biochem. Physiol. 75A:215-220.
- Chen, T.L. and D. Feldman. 1978. Glucocorticoid potentiation of the adenosine 3', 5'-monophosphate response to parathyroid hormone in cultured rat bone cells. Endocrinology 102:589-596.
- Chen, T.L. and D. Feldman. 1979. Glucocorticoid receptors and actions in subpopulations of cultured rat bone cells. Mechanism of dexamethasone potentiation of parathyroid hormone-stimulated cyclic AMP production. J. Clin. Invest. 63:750-758.
- Connerty, H. and A. Briggs. 1966. Determination of serum calcium by means of orthocresolphthalein complexone. Am. J. Clin. Pathol. 45:290-296.
- Hahn, T.J. and L.R. Halstead. 1979. Cortisol enhancement of PTH-stimulated cyclic AMP accumulation in cultured fetal rat long bone rudiments. Calcif. Tissue. Int. 29:173-175.
- Hess A.F., C.E. Bills, M. Weinstock and H. Rivkin. 1928. Differences in calcium level of the blood between male and female cod. Proc. Soc. Exp. Biol. Med. 25:349-350.
- Houston A.H. and T.F. Koss. 1984. Plasma and red cell ionic composition in rainbow trout exposed to progressive temperature increases. J. Exp. Biol. 110:53-67.
- Korkor, A., K. Martin, K. Olgaard, M. Bergfeld, S. Teitelbaum, S. Klahr and E. Slatopolsky. 1983. Altered adenosine 3', 5'-monophosphate release in response to parathyroid hormone by isolated perfused bone from glucocorticoid-treated dogs. Endocrinology 113:625-631.
- Liskova-Kiar, M. 1979. Mode of action of cortisol on bone resorption in fetal rat fibulae cultured in vitro. Am. J. Anat. 156:63-76.

- Lopez, E., E.M. Tisserand-Jochem, A. Eyquem, C. Milet, C. Hillyard, F. Lallier, B. Vidal and I. MacIntyre. 1981. Immunocytochemical detection in Stannius Corpuscles of the eel (*Anguilla anguilla* L.) of a hormone similar to mammalian parathyroid hormone. C. R. Acad. Sci. 223:707-712.
- Martem'yanov, V.I. and R.A. Zaprudnova. 1982. Electrolyte concentration dynamics in blood plasma, erythrocytes, and muscle tissue of freshwater fish under stress. Biol. Nauki. (Moscow) 10:44-49.
- Mazeaud, M.M. and F. Mazeaud. 1981. Adrenergic responses to stress in fish. In: Stress and Fish (A.D. Pickering, ed.). Academic Press, London, 49-75.
- Miescher, F. 1897. Die histochemischen und physiologischen Arbeiten. F. C. W. Vogel, Leipzig.
- Ng, B., J.W. Hekkelman and J.N.M. Heersche. 1979. The effect of cortisone on the adenosine 3',5'-monophosphate response to parathyroid hormone of bone in vitro. Endocrinology 104:1130-1135.
- Pang, P.K.T. 1973. Endocrine control of calcium metabolism in teleosts. Amer. Zool. 13:775-792.
- Pang, P.K.T. and R.K. Pang. 1986. Hormones and calcium regulation in *Fundulus heteroclitus*. Amer. Zool. 26:225-234.
- Parsons, J.A., D. Gray, B. Rafferty and J.M. Zanelli. 1978. Evidence for a hypercalcaemic factor in the fish pituitary immunologically related to mammalian parathyroid hormone. In: Endocrinology of Calcium Metabolism (D.H. Copp and R.V. Talmadge, eds.). Excerpta Medica, Amsterdam III-114.
- Patt, H.M. and A.B. Luckhardt. 1942. Relationship of a low blood calcium to parathyroid secretion. Endocrinology 31:382-392.
- Payan, P., N. Mayer-Gostan and P.K.T. Pang. 1981. Site of calcium uptake in the freshwater trout gill. J. Exp. Zool. 216:345-347.
- Rodan, S.B., M.K. Fischer, J.J. Egan, P. Epstein and G.A. Rodan. 1984. The effect of dexamethasone on parathyroid hormone stimulation of adenylate cyclase in ROS 17/2.8 cells. Endocrinology 115:951-958.
- Ruben, J.A. and A.F. Bennett. 1981. Intense exercise, bone structure and blood calcium levels in vertebrates. Nature, London 291: 411-413.
- Selye, H. 1946. The general adaptation syndrome and the diseases of adaptation. J. Clin. Endocrinol. 6:117-229.
- Tisserand-Jochem, E.M., E. Lopez, C. Milet, B. Vidal, C. Magnac, A. Eyquem and D.V. Cohn. 1987. Co-localization and secretion of parathyrin of Stannius Corpuscles (immunoreactive parathyroid-hormone) and of secretory glycoproteins including secretory protein-I in the European eel (*Anguilla anguilla* L.). Bone Miner 2:163-174.
- van Someren, V.D. 1937. A preliminary investigation into the causes of scale absorption in salmon (*Salmo salar* Linne). Fish. Bd. Scotland Salmon Fisheries.
- Wendelaar Bonga, S.E., G. Flik and J.C. Fenwick. 1984. Prolactin and calcium metabolism in fish: effects on plasma calcium and high-affinity  $\text{Ca}^{2+}$ -ATPase in gills. In: Endocrine Control of Bone and Calcium Metabolism (D.V. Cohn *et al.*, eds.). Elsevier Science Publishers B. V. 188-190.

- Wendelaar Bonga, S.E., R.K. Pang and P.K.T. Pang. 1986. Hypocalcemic effects of bovine parathyroid hormone (1-34) and Stannius Corpuscle homogenates in teleost fish adapted to low-calcium water. J. Exp. Zool. 240:363-367.
- Wiener, J.G., R.A. Jacobson, P.S. Schmidt and P.R. Heine. 1985. Serum calcium concentrations in white sucker, *Catostomus commersoni* Lacepede, and bluegill, *Lepomis macrochirus* Rafinesque, in northern Wisconsin lakes: relation to pH and waterborne calcium. J. Fish. Biol. 27:699-709.
- Zajac, J.D., S.A. Livesey, V.P. Michelangeli, S.B. Rodan, G.A. Rodan and T.J. Martin. 1986. Glucocorticoid treatment facilitates cyclic adenosine 3', 5'-monophosphate-dependent protein kinase response in parathyroid hormone-responsive osteogenic sarcoma cells. Endocrinology 118:2059-2064.
- Zar, J.H. 1974. Biostatistical Analysis. Prentice-Hall Inc., Englewood Cliffs, NJ.



## Toxic Interactions of Aflatoxin B<sub>1</sub> and Caffeine in Chromosomally Substituted Strains of *Drosophila melanogaster*

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### ABSTRACT

The effects of continuous larval exposure to 1.0 ppm aflatoxin B<sub>1</sub> (AFB<sub>1</sub>) and/or  $1 \times 10^{-2}$ M caffeine on egg-adult viability, egg-adult development times and adult female body length were determined for several wildtype strains of *Drosophila melanogaster*. A strain relatively resistant to the effects of AFB<sub>1</sub> (A-11, with chromosomes X, 2 and 3 designated "RRR") and a strain quite sensitive to AFB<sub>1</sub> toxicity (A-9 with SSS chromosomes) were intercrossed to produce three hybrid strains containing RSS, SRS, and SSR chromosome combinations. When exposed to AFB<sub>1</sub> alone, RRR = SRS > others in viability, whereas caffeine showed a significant protective effect in reducing the amount of AFB<sub>1</sub>-induced mortality in strains RRR, SRS and SSR. Generally, caffeine alone and AFB<sub>1</sub> plus caffeine caused a significant increase in egg-adult development times in all five strains, whereas AFB<sub>1</sub> alone did not. AFB<sub>1</sub> alone caused a significant decrease in female adult body length, caffeine alone did not, and larvae grown on the caffeine and AFB<sub>1</sub> mixture attained normal body lengths. These data indicate that factors on chromosome 2 confer increased resistance to AFB<sub>1</sub>-induced mortality and factors on chromosomes 2 and 3 allow caffeine to exert a protective effect.

### INTRODUCTION

Aflatoxin B<sub>1</sub> (AFB<sub>1</sub>), a natural metabolite of the fungi *Aspergillus flavus* and related species, is one of the most powerful vertebrate hepatocarcinogens and hepatotoxins known (Newberne and Butler 1969) and is an effective mutagen in a wide variety of organisms (Ong 1975). Aflatoxins also have significant larvicidal, insecticidal and chemosterilizing properties against many insect species tested (Kirk *et al.* 1971, Moore *et al.* 1978, Nguyen *et al.* 1979). In *Drosophila melanogaster*, toxic effects of growth during the larval period in media supple-

mented with low concentrations of AFB<sub>1</sub> include increased pupal and larval mortality, increased egg- pupal and egg-adult development time, decreased pupal case and adult body length, and decreased female fertility (Lalor et al. 1976).

Different vertebrate species vary in sensitivity to acute aflatoxin poisoning, with LD<sub>50</sub> values ranging from 0.3 to 17.9 mg/kg body weight (Patterson 1973). Within species, different strains of *Chlorella*, cotton, fruit flies, chickens, rats and mice display differing sensitivities to aflatoxin (see Chinnici and Melone 1985). This suggests that gene differences among strains may be responsible for the variation; autosomal gene differences affecting sensitivity to AFB<sub>1</sub> exist in *D. melanogaster* (Chinnici and Melone 1985).

Caffeine (1,3,7-trimethylxanthine), a natural metabolite of *Coffea*, *Camellia*, *Theobroma*, *Cola*, and others, produces CNS-related behavioral anomalies, cellular toxicity, and death in a large number of species (Kihlman 1977). Intra-specific variation in degree of sensitivity to caffeine-related toxicity occurs in humans (Goldstein et al. 1969), mice (Seale et al. 1984) and fruit flies (Chinnici and Bettinger 1984). Caffeine reduces the toxic effects of other chemical agents in rats (White et al. 1984) and *Drosophila* larvae (Nigsch et al. 1977). Regarding the interaction of AFB<sub>1</sub> and caffeine, Cramer and Painter (1981) reported that the inhibitory effect of AFB<sub>1</sub> on DNA replicon initiation in HeLa cells was largely prevented by caffeine. Also, the toxic effects of dietary AFB<sub>1</sub> are significantly reduced when caffeine is also added to the culture medium of several wild- type strains of *D. melanogaster* (Chinnici and Bettinger 1984).

The studies presented below measure the interactions of AFB<sub>1</sub> and caffeine in five strains of fruit flies, two parental and three produced by intercrossing the parents to produce strains with known combinations of parental chromosomes. These studies demonstrate the effect of different chromosome contributions on the degree of sensitivity to AFB<sub>1</sub>, and the degree of protection afforded by caffeine.

## MATERIALS AND METHODS

**INSECTS.** Two standard outbred laboratory strains of *D. melanogaster* were used, Lausanne-S (A-11) and Florida-9 (A-9), obtained from the Mid-America *Drosophila* Center, Bowling Green OH, and were maintained by mass culture. A special strain, CMI (complete multiple inversion), containing multiply inverted chromosomes was generously provided by T.R.F. Wright of the University of Virginia, Charlottesville. See Chinnici (1980) for a description of this strain.

**CHEMICALS AND CULTURE MEDIUM.** The culture medium consisted of yeast, dextrose, agar and several inorganic salts, with tegero-sept added as a mold inhibitor (Chinnici 1970). Control (no AFB<sub>1</sub> or caffeine) and stock solutions containing 1.0 ppm AFB<sub>1</sub> (Grade A, Calbiochem-Behring, LaJolla CA) alone, 10<sup>-2</sup>M caffeine alone and a mixture of 1.0 ppm AFB<sub>1</sub> and 10<sup>-2</sup>M caffeine were produced. These were poured into a series of 8-dram shell vials (8 ml medium per vial), stoppered with foam plugs and refrigerated until used. All experiments were performed at 25 ± 1°C.

**EXPERIMENTAL PROCEDURES.** The CMI strain was crossed to both A-9, a strain sensitive to AFB<sub>1</sub> mortality, and A-11, a relatively resistant strain.































STRAINS	CHROMOSOMES		
	X	2	3
LAUSANNE S A-11 (RRR)	 	 	 
FLORIDA 9 A-9 (SSS)	 	 	 
R-X (RSS)	 	 	 
R-2 (SRS)	 	 	 
R-3 (SSR)	 	 	 

Figure 1. The chromosome constitutions of strains R-X, R-2, and R-3 and the parental strains A-11 (Lausanne-S) and A-9 (Florida-9) from which they were constructed by chromosome substitution.

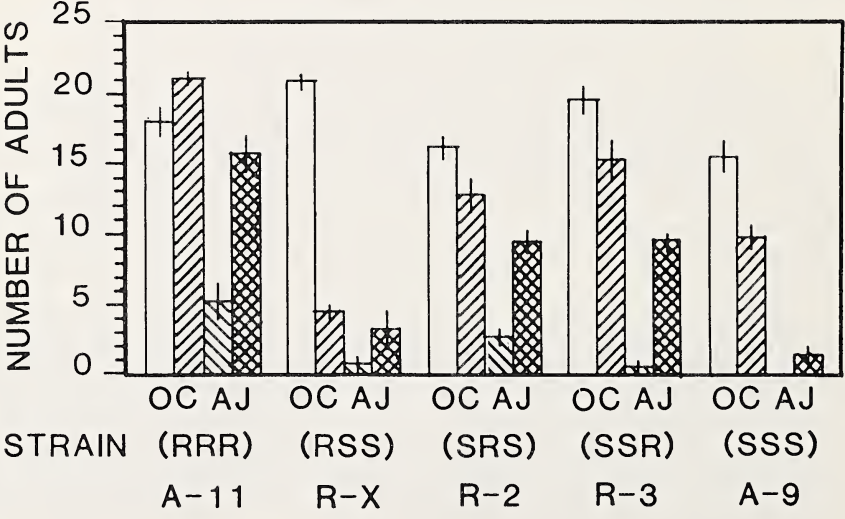


Figure 2. Number of adults (mean  $\pm$  standard error) per vial (6 replications, 25 eggs per vial); control (O),  $1.0 \times 10^{-2}$  M caffeine (C), 1.0 ppm AFB<sub>1</sub> (A) and caffeine plus AFB<sub>1</sub> (J) treatments.



Through a series of matings similar to those described in Chinnici (1980), five strains were constructed: the original A-9 with sensitive chromo-somes X, 2 and 3 ("SSS"), the original A-11 with resistant chromosomes X, 2 and 3 ("RRR") and the substituted strains R-X ("RSS"), R-2 ("SRS") and R-3 ("SSR"). Figure 1 illustrates the relationship of these five strains.

Flies from the five strains were allowed to lay eggs for 12 hr in half pint culture bottles containing control medium. The eggs were then collected, and groups of 25 were placed on small squares of moistened blotting paper. Each shell vial containing medium received a group of 25 eggs, and each of the four treatments (control, AFB<sub>1</sub> alone, caffeine alone, AFB<sub>1</sub> and caffeine) was replicated six times. As the cultures developed, data were collected daily on egg-adult viability, development time and adult female body length (tip of head to tip of abdomen).

## RESULTS

The data generated from these studies are summarized in Table 1. The mortality data are graphically represented in Figure 2. All five strains demonstrate significant egg-adult mortality when exposed to AFB<sub>1</sub> alone. However, the greatest difference exists between strains A-11 and A-9 and indicates that the former is the most resistant strain while the latter is the most sensitive. The substituted strains fall between these extremes with R-2 being the least sensitive of the three. These results suggest the presence of genetic factors on chromosome 2 for resistance to AFB<sub>1</sub> toxicity. Strains A-9 and R-X are the most sensitive to AFB<sub>1</sub> toxicity. When AFB<sub>1</sub> and caffeine are administered together, caffeine has a positive effect on viability, though significantly so only in strains A-11, R-2, and R-3, all of which contain chromosomes 2 and/or 3 of resistant origin. The protective effect of caffeine is reduced in strains containing chromosomes 2 and 3 of sensitive origin (A-9, R-X). In these latter strains, caffeine itself may be sufficiently deleterious that any potential protection against AFB<sub>1</sub> toxicity is reduced.

Egg-adult development time shows that exposure to AFB<sub>1</sub> alone increases development time slightly, but insignificantly, while caffeine alone causes a significant increase. Joint exposure also produces significantly longer development time. Although caffeine may attenuate the lethal effects of AFB<sub>1</sub>, the surviving flies develop at a much slower rate, indicating that caffeine stresses and prolongs the developmental process, perhaps by decreasing the rate of cell division and slowing the rate of DNA synthesis. However, the longer developmental time induced by caffeine in the joint exposures generally allow female larvae to develop into adults of normal or near-normal body lengths even though AFB<sub>1</sub> alone causes significant reductions.

## DISCUSSION

In eukaryotic cells, aflatoxin causes multiple molecular injuries involving DNA structure and synthesis of RNA and protein (Mainigi and Campbell 1980). The cytochrome P-450 mixed function oxidase (MFO) system activates AFB<sub>1</sub> by producing the 2,3-epoxide which readily binds to DNA at guanine sites (Fahmy et al. 1978). Decreased AFB<sub>1</sub> binding to DNA occurs by conjugation

Table 1. Egg-adult viability and development times and adult female body lengths for controls and caffeine and/or AFB1 treatments.

STRAIN	CAFFEINE ( $\times 10^{-2}M$ )	Number of adults enclosed per vial ( $\bar{x} \pm SEM$ ) <sup>a</sup>		Adult development time in days ( $\bar{x} \pm SEM$ ) <sup>a</sup>		Adult female body length in mm ( $\bar{x} \pm SEM$ ) <sup>a</sup>	
		AFLATOXIN B1 (ppm)	AFLATOXIN B1 (ppm)	AFLATOXIN B1 (ppm)	AFLATOXIN B1 (ppm)	AFLATOXIN B1 (ppm)	AFLATOXIN B1 (ppm)
Lausanne-S (RRR)	0.0	18.00 $\pm$ 0.96	5.33 $\pm$ 1.21 <sup>b</sup>	10.62 $\pm$ 0.18	11.46 $\pm$ 0.35	3.04 $\pm$ 0.01	2.87 $\pm$ 0.05 <sup>b</sup>
	1.0	21.00 $\pm$ 0.05	15.80 $\pm$ 1.25 <sup>c</sup>	15.18 $\pm$ 0.16 <sup>b</sup>	16.06 $\pm$ 0.45 <sup>b</sup>	3.05 $\pm$ 0.08	2.99 $\pm$ 0.04
R-X (RSS)	0.0	20.80 $\pm$ 0.56	0.67 $\pm$ 0.45 <sup>b</sup>	10.22 $\pm$ 0.41	13.00	3.04 $\pm$ 0.02	2.67 $\pm$ 0.14 <sup>b</sup>
	1.0	4.50 $\pm$ 0.52 <sup>b</sup>	3.17 $\pm$ 1.57 <sup>b</sup>	17.58 $\pm$ 0.38 <sup>b</sup>	17.98 $\pm$ 0.28 <sup>bc</sup>	3.00 $\pm$ 0.14	2.93 $\pm$ 0.05 <sup>c</sup>
R-2 (SRS)	0.0	16.17 $\pm$ 0.69	2.83 $\pm$ 0.37 <sup>b</sup>	10.18 $\pm$ 0.25	13.00 $\pm$ 0.84	3.02 $\pm$ 0.09	2.73 $\pm$ 0.10 <sup>b</sup>
	1.0	12.83 $\pm$ 1.02	9.50 $\pm$ 0.73 <sup>bc</sup>	17.35 $\pm$ 0.45	17.60 $\pm$ 0.29 <sup>bc</sup>	3.05 $\pm$ 0.10	3.02 $\pm$ 0.07 <sup>c</sup>
R-3 (SSR)	0.0	19.50 $\pm$ 0.84	0.50 $\pm$ 0.20 <sup>b</sup>	10.50 $\pm$ 0.23	14.00 $\pm$ 0.94	2.95 $\pm$ 0.04	3.00
	1.0	15.33 $\pm$ 1.18	9.33 $\pm$ 0.19 <sup>bcd</sup>	15.78 $\pm$ 0.51 <sup>b</sup>	16.28 $\pm$ 0.38 <sup>b</sup>	3.02 $\pm$ 0.15	3.03 $\pm$ 0.04
Florida-9 (SSS)	0.0	15.50 $\pm$ 0.94	0	9.97 $\pm$ 0.04	17.50 $\pm$ 0.26 <sup>b</sup>	3.06 $\pm$ 0.04	2.56 $\pm$ 0.04 <sup>d</sup>
	1.0	9.83 $\pm$ 0.52 <sup>b</sup>	1.33 $\pm$ 0.38 <sup>bd</sup>	16.95 $\pm$ 0.41 <sup>b</sup>		2.87 $\pm$ 0.05	

a. For each strain, each of the four treatments was replicated six times; each treatment vial initially received 25 eggs.

b. Significant difference between control (no AFB1 or caffeine) and treatment (analysis of variance,  $P < 0.05$ ).c. Significant difference between 0 caffeine/1.0 AFB1 and 1.0 caffeine/1.0 AFB1 (analysis of variance,  $P < 0.05$ ).d. Significant difference between 1.0 caffeine/0 AFB1 and 1.0 caffeine/1.0 AFB1 (analysis of variance,  $P < 0.05$ ).

with glutathione (GSH) due to glutathione S-transferase and leads to decreased cytotoxicity with low levels of AFB<sub>1</sub> (Lotikar et al. 1980, Neal et al. 1981). Differential glutathione S-transferase-AFB<sub>1</sub> binding activities are related to the relative resistance of a species to AFB<sub>1</sub> (Lotikar et al. 1984).

Caffeine has an affinity for double-stranded DNA with short single-stranded regions to which it hydrogen bonds at low concentrations, and causes a conformational change in the DNA structure (Pohle and Fritzsche 1981). Caffeine increases the number of replication origins utilized during S-phase duplication and causes the genome to be replicated in smaller sections (Tatsuma and Strauss 1979); but by slowing down initiation of synthesis, caffeine also inhibits semi-conservative replication (Painter 1982). Caffeine protects mice and hamsters by inhibiting tumorigenesis caused by exposure to mutagens and by injected transformed cells (Theiss and Shimkin 1978, Nomura 1980). Caffeine inhibits tumor formation in a tumor-prone strain of *Drosophila* (Ghelelovitch 1975).

Caffeine may affect activation, metabolism, or binding of AFB<sub>1</sub>, or repair of DNA damage caused by AFB<sub>1</sub>. Caffeine may even allow cells to ignore the damage done by AFB<sub>1</sub>; caffeine can cause DNA polymerase to "jump" bound adducts instead of stalling and to reinitiate beyond the adduct (van den Berg and Roberts 1976), allowing cells to duplicate under conditions otherwise inhibitory for DNA synthesis. AFB<sub>1</sub> is an inhibitor of replicon initiation in cultured HeLa cells. Upon addition of caffeine, however, normal replicon initiation is stimulated even with the AFB<sub>1</sub> adducts present (Cramer and Painter 1981). Thus, caffeine may cause a change in chromatin structure so that cells no longer must react to DNA damage by ceasing DNA synthesis (Painter 1982).

Since dietary chemicals may induce the activity of the microsomal (MFO) enzymes (Shelton et al. 1984), caffeine may affect the MFO metabolism of AFB<sub>1</sub>. Caffeine may enhance glutathione S-transferase enzyme activity that leads to an increase in AFB<sub>1</sub>-GSH conjugation (Younes et al. 1980). Another possibility is that caffeine may inhibit AFB<sub>1</sub>-adduct binding to DNA since it inhibits binding of the adduct dimethylbenz (a)anthracene in cultured cell DNA (Shoyab 1979). Elucidation of the exact mechanism responsible for the attenuation of AFB<sub>1</sub>-induced toxicity by caffeine is the subject of further research of a physiological nature.

#### LITERATURE CITED

- Chinnici, J.P. 1970. Polygenic control of recombination frequency in *Drosophila melanogaster*. Ph.D. Thesis, University of Virginia.
- Chinnici, J.P. 1980. Genetic resistance of Aflatoxin B<sub>1</sub> toxicity in *Drosophila melanogaster*: Chromosome substitution analysis. *J. Hered.* 77:275-278.
- Chinnici, J.P., and Bettinger, D.A. 1984. Effects of Aflatoxin B<sub>1</sub> and caffeine on viability in natural strains of *Drosophila melanogaster*. *J. Invertebr. Pathol.* 44:263-266.
- Chinnici, J.P., and Melone, P.M. 1985. Genetic aspects of Aflatoxin B<sub>1</sub> resistance in *Drosophila melanogaster*. *J. Hered.* 76:85-88.



- Cramer, P., and Painter, R.B. 1981. Effects of activated Aflatoxin B<sub>1</sub> and caffeine on DNA replicon initiation in HeLa cells. *Carcinogenesis*. 2:379-384.
- Fahmy, M.H., Fahmy, O.G., and Swenson, D.H. 1978. Aflatoxin B<sub>1</sub>-2-3-dichloride as a model of the active metabolite of Aflatoxin B<sub>1</sub> in mutagenesis and carcinogenesis. *Cancer Res.* 38:2608-2616.
- Ghelelovitch, S. 1975. Effet de la cafeine sur le developpement des tumeurs melaniques chez la *Drosophila*. *Mutation Res.* 28:221-226.
- Goldstein, A., Kaizer, S., and Whitley, O. 1969. Phenotypic effects of caffeine in man. IV. Quantitative and qualitative differences associated with habituation to coffee. *Clin. Pharmacol. Exp. Ther.* 10:489-497.
- Kihlman, B.A., 1977. *Caffeine and Chromosomes*. Elsevier Scientific Publ. Co., Amsterdam, New York, and Oxford. 504 pages.
- Kirk, H.D., Ewen, A.B., Emson, H.E., and Blair, D.G.R. 1971. Effect of Aflatoxin B<sub>1</sub> on development of *Drosophila melanogaster* (Diptera). *J. Invertebr. Pathol.*, 18: 313-315.
- Lalor, J.H., Chinnici, J.P., and Llewellyn, G.C. 1976. Effects of a fungal metabolite, Aflatoxin B<sub>1</sub>, on larval viability and gross morphology in *Drosophila melanogaster*. *Dev. Ind. Microbiol.* 17:443-449.
- Lotikar, P.D., Insetta, S.M., Lyons, P.R., and Jhee, E. 1980. Inhibition of microsome-mediated binding of Aflatoxin B<sub>1</sub> to DNA by glutathione S-transferase. *Cancer Letters* 9:143-149.
- Lotikar, P.D., Jhee, E.C., Insetta, S.M., and Clearfield, M. S. 1984. Modulation of microsome-mediated Aflatoxin B<sub>1</sub> binding to exogenous DNA by cytosolic glutathione S-transferases in rat and hamster livers. *Carcinogenesis* 5:269-276.
- Mainigi, K.D., and Campbell, T.C. 1980. Subcellular distribution and covalent binding of aflatoxins as functions of dietary manipulation. *J. Tox. and Evt. Health* 6:659-671.
- Moore, T.H., Hammond, A.M., and Llewellyn, G.C. 1978. Chemo-sterilant and insecticidal activity of mixed aflatoxins against *Anthonomous grandis Bohemia* (Coleoptera). *J. Invertebr. Pathol.* 31:365-367.
- Neal, G.E., Metcalfe, S.A., Legg, R.F., Judah, D.J., and Green, J.A. 1981. Mechanism of the resistance to cytotoxicity which precedes Aflatoxin B<sub>1</sub> hepato-carcinogenesis. *Carcinogenesis* 2:457-461.
- Newberne, P.M. and Butler, W.H. 1969. Acute and chronic effects of Aflatoxin on the liver of domestic animals: a review. *Cancer Res.* 29:236-250.
- Nguyen, T.D., Boyd, J.B., and Green, M.M. 1979. Sensitivity of *Drosophila* mutants to chemical carcinogens. *Mutation Res.* 63:67-77.
- Nigsch, J., Graf, V., and Wurgler, F.E. 1977. Caffeine toxicity in *Drosophila* strains having different MMS insensitivities. *Mutation Res.* 43:57-64.
- Nomura, T. 1980. Timing of chemically induced neoplasia in mice revealed by the antineoplastic action of caffeine. *Cancer Res.* 40:1332-1340.
- Ong, T.M. 1975. Aflatoxin mutagenesis. *Mutation Res.* 32:35-53.
- Painter, R.B. 1982. Structural changes in chromatin as the basis for radiosensitivity in ataxia telangiectasia. *Cytogenet. Cell Genet.* 33:139-144.
- Patterson, D.S.P. 1973. Metabolism as a factor in determining the toxic action of the aflatoxins in different animal species. *Food. Cosmet. Toxicol.* 11:287-294.

- Pohle, W., and Fritzache, H. 1981. DNA-caffeine interactions. Evidence of different binding modes by infrared spectroscopy. *Studia Biophys.* 82:81-96.
- Seale, T.W., Johnson, P., Carney, J.M., and Rennert, O.M. 1984. Interstrain variation in acute toxic response to caffeine among inbred mice. *Pharmacol. Biochem. Behav.* 20:567-573.
- Shelton, D.W., Hendricks, J.D., Coulombe, R.A. and Bailey, G. S. 1984. Effect of dose on the inhibition of carcinogenesis/ mutagenesis by Aroclor 1254 in rainbow trout fed Aflatoxin B<sub>1</sub>. *J. Tox. Evt. Health* 13:649-657.
- Shoyab, M. 1979. Caffeine inhibits the binding of Dimethylbenz(a)anthracene to murine epidermal cell DNA in culture. *Arch. Biochem. Biophysics* 196:307-310.
- Tatsumi, K., and Strauss, B.S. 1979. Accumulation of DNA growing points in caffeine-treated human lympho-blastoid cells. *J. Mol. Biol.* 135:435-449.
- Theiss, J.C., and Shimkin, M.B. 1978. Inhibiting effect of caffeine on spontaneous and urthan-induced lung tumors in strain A mice. *Cancer Res.* 38:1757-1761.
- van den Berg, H.W., and Roberts, J.J. 1976. Inhibition by caffeine of post-replication repair in chinese hamster cells treated with cis-platinum (II) diamminedichloride: The extent of platinum binding to template DNA in relation to the size of low molecular weight nascent DNA. *Chem.-Biol. Interactions* 12:375- 390.
- White, B.C., Haswell, K.L., Kassab, C.D, Harkins, D., and Crumbie, P.M. 1984. Caffeine reduces amphetamine- induced activity in asymmetrical interaction. *Pharmacol. Biochem. Behav.* 20:387-389.
- Younes, M., Schlichting, R., and Siegers, C.P. 1980. Glutathione S-transferase activities in rat liver: Effect of some factors influencing the metabolism of xeno-biotics. *Pharm. Res. Commun.* 12:115-129.

## *Chymomyza amoena* (DIPTERA: DROSOPHILIDAE), An Unusual Urban Drosophilid

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### ABSTRACT

*Chymomyza amoena* females, from early June onwards, can make use of a variety of substrates in the urban environment for egg deposition. Prior pest attack assures access to immature firm fallen fruits. Ornamental crabapples are also found to harbor major fruit pest larvae in August.

### INTRODUCTION

*Chymomyza amoena* (Loew), a cold hardy drosophilid, has been reported in a variety of habitats in the mid-West (Steyskal, 1952; Oatman *et al*, 1964; Sabath and Jones, 1973; Band and Band, 1980, 1982, 1984). Adults have been collected around the cut ends of trees in Michigan (Steyskal), in the trees in an apple orchard (*Malus pumila*) in Wisconsin (Oatman *et al*), and in gardens and forests in Indiana (Sabath and Jones). Band and Band have obtained larvae from apples, black walnut husks (*Juglans nigra*), native crabapples (*Malus coronaria*), and ornamental crabapples (varieties *Strathmore* and *Radiantia*) for coldhardiness studies. Prof. Davis at Michigan Agricultural College bred them from apples along with codling moth (*Cydia pomonella*) in 1891. Wheeler (1952, 1965) reports this species throughout the east and as far west as Nebraska, Utah and Arizona.

*Chymomyza* eggs are distinctive (Throckmorton, 1962; Hackman *et al*, 1970). McCoy (1962) argued that fruit-breeding *Drosophila* sp. oviposit only on ripe fruits at or near ground level (but see Sieger and Khamis, 1987). Band and Band (1983) found *C. amoena* ovipositing on pears (*Pyrus communis*) in a tree in late August. Carson and Heed (1983) pointed out that drosophilids require damaged fruits for oviposition.

Cold hardiness expression is strongly influenced by environment (Baust, 1981; Band and Band, 1984). However, Weatherhead (1986) criticized researchers for invoking unusual events (weather, biotic factors) in interpreting data from field studies of two and three years duration.

The biology of *C. amoena* has been investigated in Michigan and Virginia in the 1980's in a variety of intra- and interstate localities (Band, 1988). Here I report studies on oviposition behavior carried out in a totally urban setting in East Lansing, Michigan. Interspecies dependency for the invasion of all niches also points to the urban environment as a reservoir for true fruit pests.



## MATERIALS AND METHODS

The three principal sites used in this study are two adjacent (B1, B3) and one (B2) nearby lot having a variety of fruit trees in a housing development barely two decades old, which was formerly a farm. With the exception of a few existing trees, including several black walnuts, all lots have been landscaped by the original owners. Fruit trees are (were) typical nursery stock obtained from local gardening stores or catalog companies. B1 had an apple, pear (*Pyrus communis*), peach (*Prunus persica*), and two sweet cherry (*Prunus avium*) trees until the first three were cut down in 1987. B3 has an apple, three pyramidal ornamental crabapples, two standard ornamental crabapples and two pear trees. B2 has a plum (*Prunus* sp.) and two apple trees. The original Lansing site (designated A), a farm west of the city where *C. amoena* were observed displaying on small immature fallen domestic apples in early July 1981 (Band, 1988), was included in the study in 1984. The data in the present study were obtained in 1983, 1984, and 1987.

In 1983 immature fallen apples were gathered at B1 in the first and second weeks of July and location of eggs scored in relation to frass (insect excreta) present. Apples were dissected if no frass was visible from the exterior. Apples from the tree were also sampled. In 1984 a cool spring delayed blooming and fruit set. Collections were made at B1 and A in early July. At B1 all apples on the ground were gathered in late July and again in August and eggs scored.

In 1987 fallen plums and apples at B2 were gathered beginning in early June. Sampling was continued through early July. Numbers of eggs per fruit were counted. Plums were also classified as unripe (green) or prematurely ripe (purple), apples as immature unripe (green) or rotting (brown). All the early-collected fruits were on the ground. In mid-August apples and ornamental crabapples were collected at B3 and apples from the tree were also sampled. Fruits were either ripe (red) or rotting (brown). Red ornamental crabapples however are firm.

The 1983 data provide a measure of the tendency of females to oviposit in immature unripe fallen frassy fruits and also to oviposit in parasitized fruits on trees. The 1987 data provide a measure of niche utilization.

Data analyses have employed the Poisson and negative binomial, and the analysis of variance using the Sokal and Rohlf Stat-Pac. Chi-square comparisons have been computed according to Strickberger (1985).

## RESULTS

Table 1 shows the number of fruits containing *C. amoena* eggs in each collection. Apples gathered from the trees in 1983 and 1987 had *C. amoena* eggs, although this species makes predominant use of fallen fruits (Band, 1988). Fruit utilization beginning with unripe plums in early June in the urban Michigan environment, continues in unripe apples also in June. By August ornamental crabapples are invaded in addition to apples. In June plums, and the small dropped apples also, usually have plum curculio (*Conotrachelus nenuphar*) scars. Later in summer apples are in a riper stage. This species can utilize both immature unripe and ripe apples.

Oviposition on apples in early July 1984 was delayed. Over 200 immature fallen apples had littered the ground in the second week of July 1983 and all

Table 1. Oviposition data of *Chymomyza amoena* in an East Lansing, MI neighborhood.

Year	Site	Date	Location	Fruit	Number	Number with eggs	Number of eggs
1983	B1	July 1	ground	apples	30	11	43
		July 7	tree	apples	5	2	7
			ground	apples	7	7	41
1984	B1	July 7	ground	apples	15	1	2
	A*	July 7	ground	apples	15	2	13
	B1	July 25	ground	apples	105	10	72
		Aug 25	ground	apples	12	11	110
1987	B2	June 8	ground	plums	93	14	41
		June 15	ground	plums	39	11	16
				apples	9	1	3
		June 21	ground	plums	38	8	24
				apples	33	5	14
		June 29	ground	plums	33	8	18
	B3	July 3	ground	apples	17	7	28
				plums	12	6	10
				apples	58	32	235
		Aug. 18	tree	apples	12	2	2
			ground	apples	29	25	122
			ground	o.c**	111	17	33

\*A = original site west of Lansing; \*\* = ornamental crabapples

seven frassy apples gathered had almost as many eggs as 11 of 30 collected the first week. However, only one of the few available in the same week in 1984 had *C. amoena* eggs. Apples at A, west of Lansing, also showed few *C. amoena* eggs on the same date. On 25 July 1984, of the 105 apples at B1, only 18 had *C. amoena* eggs, suggesting clustering (Atkinson and Shorrocks, 1984). Apples had been heavily parasitized; 66 of 72 eggs were in frass. Most apples had been picked up and discarded by 25 August, however 12 apples found on that date had a total of 110 eggs in 11 of them. This is also the only group of apples to have *Drosophila* sp. eggs in contrast to early sharing in North Carolina (Band, 1985).

Table 2. confirms that females oviposit typically on frassy apples in early summer. Egg distribution was similar in both weeks, so samples were combined. The preference for previously parasitized apples (98% of all eggs) is significant ( $X^2_1 = 84.11$ ,  $P < 0.001$ ).

Emergence data were obtained from the 1987 June/July collections. From the June 8th plums, 25 adults emerged, 9 from the June 15th plums and apples, 20 plus one codling moth from the June 21st plums and apples, 9 plus one plum curculio weevil from the June 29th collection and 110 from the July 3rd collection. Less than half the eggs laid result in an imago, again a result nonunique to Michigan *C. amoena* in summer (Band, 1988). High mortality has also been observed in winter (Band and Band, 1987). Flies emerging were not sexed but transferred directly to food vials for other work.

Atkinson and Shorrocks (1984) have argued that fruit-breeding Diptera have a negative binomial distribution over fruit items and are highly aggregated. Table 3 shows the total number of fruits per collection in 1987, mean number

Table 2. Placement of *Chymomyza amoena* eggs on small frassy apples in 1983

Apples	Stem	Calyx	Hole/Scar	Total
frass	2	6	10	18
frass inside	19	19	33	71
no frass	2	0	0	2

Table 3. Comparison of the mean number of *Chymomyza amoena* eggs per fruit and negative binomial  $k$  values for the 1987 sample.

Fruit	Collections	N	mean per fruit	$k$ value
plums	June 8	93	0.44	0.097
	June 15, 21	77	0.52	0.224
	June 29, July 3	46	0.61	0.397
apples	June 15, 21	42	0.41	0.093
	June 29, July 3	75	3.49	0.277
	Aug. 18	41	3.02	0.494
ornamental crabapples	Aug. 19	111	0.43	0.162

of eggs per fruit and negative binomial  $k$  values for early, mid and late June (including July samples) plums and apples and for apple and ornamental crabapple collections in August. Goodness-of-fit tests using estimated  $k$  values gave excellent agreement to the negative binomial, whereas application of the Poisson to the egg distribution in each data set was significant. From Table 1, at site B2 in 1987 the 47 plums with *C. amoena* eggs had a mean number of 2.10 eggs each, the 45 apples a mean of 6.22 eggs each, indicating clustered egg laying, typical of most *Drosophila* (Atkinson and Shorrocks, *ibid.*). Among the 18 August 1987 apples, seven had a total of 35 hatched and unhatched eggs of which 16 looked new. *Chymomyza amoena* females will oviposit where others of their species have oviposited (Band, 1988).

*Chymomyza amoena* larvae shared rotting ornamental crabapples with pest larvae. Plum curculio, codling moth, apple maggot (*Rhagoletis pomonella*), and lesser apple worm (*Grapholitha prunivora*) larvae were present.

The mean number ( $\pm$  SE) of eggs over all apples is  $2.31 \pm 0.96$  in 1987. For all plums and ornamental crabapples collected with the apples, this value is  $0.50 \pm 0.4$ , not significantly different ( $F_{1,5} = 5.06$ ).  $k$  values between these two groups do not differ significantly and are in agreement with observed values for other *Drosophila* species on natural substrates (Atkinson and Shorrocks, 1984). Aggregation can arise from multiple causes, all of which seem displayed by *C.*



*amoena* females: true contagion where the presence of an egg stimulates oviposition by a female of the same species, eggs laid in clusters, variation in quality within fruits.

Nevertheless, niche utilization and niche preference changes. *Chymomyza amoena* females initially oviposit in unripe fallen plums. On 21 June they are equally divided between premature ripe plums (6) and immature apples (5). By 3 July most are ovipositing in immature fallen apples (32). By 3 July females also oviposit in the few fallen apples at B3, indicating that in previous years *C. amoena* coming to B1 were mostly immigrants from the nearby site.

## DISCUSSION

Heretofore, the African lissocephalids, the most primitive Drosophilidae (Throckmorton, 1975) were the only drosophilids known to utilize unripe un-fallen fruits, figs (*Ficus* sp.) (Lachaise, 1977; Lachaise and Tsacas, 1983). These females, too will oviposit around holes made by *Pyrilidae* caterpillars or fig weevil larvae, if available (Lachaise, 1977). Lissocephalid larvae are yeast feeders and are not feeding on the immature fruit flesh (Lachaise and Tsacas, 1983). Given that *C. amoena* females are choosing parasitized unripe fruits among the early fallen plums and apples, and larvae are frass feeders (Band and Band, 1984), it is doubtful if toxicity of green fruits presents a problem.

Frass feeding has been reported for 3 drosophilids in Hawaii (Heed, 1968) and among drosophilids in the Cameroons (Lachaise and Tsacas, 1983). Wallace (1978) was able to adapt *D. virilis* to a high urea environment after Carson (1974) reported two *Drosophila* and a lissocephalid species each breeding in the nephritic gills of crabs. Hence the capacity to adapt to a high urea/ nitrogen environment exists in several genera of drosophilids.

The fact that *C. amoena* was breeding in immature plums along with plum curculio (all plums were scarred) also suggests that this is an ancient association. Both insect species are native to North America as are several varieties of plums (Wyman, 1971). Jefferson recorded wild plums among the fruits native to Virginia (Peden, 1955) and reported weevils attacking "young plums, apricots, nectarines and peaches" in 1791 in Pennsylvania (Betts, 1944, p. 163). The fact that *C. amoena* females switch from premature ripe fallen plums (plums on the tree were still green) to immature apples explains past failure to find this species in ripe fallen plums previously. It also indicates that *C. amoena* was preadapted to follow plum curculio and other insect pests into the domestic (imported) apple and that the association in the East may indeed date from the 18th century, where this species can be found in entomology collections in apple-producing states as Pennsylvania and Virginia, confirming Wheeler (1952).

The resulting polyphagy is a polyphagy that has a common theme, insect parasitism. It also creates a "domestic" species (Dobzhansky, 1965) of likely prehistoric vintage. Other niches, acorns (Sturtevant, 1921) and native crabapples (Band and Band, 1984) were food sources for North American Indians. It also provides another example of interspecies dependency. *Chymomyza amoena* females need other species to attack substrates which are firm. It also indicates that prior pest attack is a likely factor contributing to variation in fruit quality leading to *C. amoena* egg aggregation (Band, 1988).

Interspecies dependency has been found to span the biological gamut. Examples include: the large blue butterfly (*Maculinea arum*) (Ratcliff, 1979; Dobson and May, 1986; Wilcove et al, 1986); the relation between pines (*Pinus* sp.), red-cockaded woodpeckers (*Picoides borealis*), flying squirrels (*Glaucomys volans*) and fungi (*Phellijus pini*) (Jackson and Jackson, 1985; Ligon et al, 1986); dependency of 4 species of Central American frogs on muddy wallows made by the collard peccary (*Tayassu pecari*) (Zimmerman and Bierragaard, 1986) and the relation between some pollinators, dispersers and plants (Gilbert, 1980; Terbough, 1986).

The start of the breeding season is as subject to weather factors as is the development of increased cold hardiness in fall and winter, including supercooling point elevation among freeze tolerant *C. amoena* larvae (Band and Band, 1984) and the onset of proline accumulation (Band and Band, 1987). Real populations exist in the real world. How populations respond to unusual events can provide important data, a fact which Weatherhead (1986) overlooks.

To date, however, *C. amoena* is the only drosophilid breeding in immature frassy fruits in Michigan. It is also the only drosophilid in this niche in Virginia's Allegheny Mountains (Band, 1988).

Atkinson and Shorrocks (1984) reported no insects in fallen damaged ornamental plums (*Prunus cerasifera*) in Scotland other than *D. subobscura*. This is not the case with ornamental crabapples in East Lansing, Michigan. The fact that larvae of the major apple and other fruit pests can be in ornamental crabapples by mid-August indicates the urban environment acts as a reservoir for orchard pests. It also indicates that despite the practice of homeowners to discard the large quantities of unusable fruits, the ornamentals also provide larval feeding niches. Whether or not this leads to successful overwintering depends upon the species, oviposition date, developmental rate and overwintering stage. For *C. amoena*, larval coldhardiness and frass feeding assure it a permanent place in the urban environment when a variety of fruits are available and plum curculio and codling moth are established residents also.

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#### LITERATURE CITED

- Alcock, J. 1973. Notes on a nesting aggregation of digger wasps in Seattle, Washington (Hymenoptera). *Wasmann J. Biol.* 31: 323-336.
- Atkinson, W. D. and B. Shorrocks. 1984. Aggregation of larval Diptera over discrete and ephemeral breeding sites: The implications for coexistence. *Amer. Nat.* 124: 336-351.
- Band, H. T. 1985. Is *Chymomyza amoena* a domestic species? *Genetics* 110: s88-s89.



- \_\_\_\_\_. 1988. Host shifts of *Chymomyza amoena* (Diptera: Drosophilidae) Amer. Midl. Nat. (in press).
- Band, H. T. and R. N. Band. 1980. Overwintering of *Chymomyza amoena* larvae in apples in Michigan and preliminary studies on the mechanism of cold hardiness. *Experientia* 36: 1182-1183.
- \_\_\_\_\_ and \_\_\_\_\_. 1982. Multiple overwintering mechanisms by *Chymomyza amoena* (Diptera: Drosophilidae) in Michigan and laboratory induction of freeze tolerance. *Experientia* 38: 1448-1449.
- \_\_\_\_\_ and \_\_\_\_\_. 1983. Multiple host plant utilization via interspecies dependency and behavioral changes in *Chymomyza amoena* in Michigan. *Genetics* 104: s4.
- \_\_\_\_\_ and \_\_\_\_\_. 1984. A mild winter delays supercooling point elevation in freeze tolerant *Chymomyza amoena* larvae (Diptera: Drosophilidae). *Experientia* 43: 1027-1029.
- \_\_\_\_\_ and \_\_\_\_\_. 1987. Amino acid and allozyme changes in overwintering *Chymomyza amoena* larvae (Diptera: Drosophilidae). *Experientia* 43: 1027-1029.
- Baust, J. G. 1981. Biochemical correlates to cold hardening in insects. *Cryobiology* 18: 186-198.
- Betts, E. M. 1944. Thomas Jefferson's Garden Book 1766-1824. Amer. Phil. Soc., Philadelphia. xiv + 704 pp.
- Carson, H. L. 1974. Three flies and three islands: Parallel evolution in *Drosophila*. *Proc. Nat. Acad. Sci.* 71: 3517-3521.
- Carson, H. L. and W. B. Heed. 1983. Methods of collecting *Drosophila*. pp. 1-59 in M. Ashburner, H. L. Carson and J. T. Thompson, Jr. (eds.) *Genetics and Biology of Drosophila*. Vol. 3d. Academic, London.
- Dobzhansky, T. 1965. "Wild" and "domestic" species of *Drosophila*. pp. 533-546 in G. Baker and G. L. Stebbins (eds.). *The Genetics of Colonizing Species*. Academic Press, New York.
- Dobson, A. P. and R. M. May. 1986. Disease and conservation. pp. 345-365 in M. E. Soule (ed.). *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer, Sunderland, MA.
- Gilbert, L. E. 1980. Food web organization and conservation of neotropical diversity. pp. 11-34 in M. E. Soule and B. A. Wilcox (eds.). *Conservation Biology: An Evolutionary-Ecological Perspective*. Sinauer, Sunderland, MA.
- Hackman, W., S. Lakovaara, A. Saura, M. Sorsa and K. Vepsäläinen. 1970. On the biology and karyology of *Chymomyza costata* Zetterstedt with reference to the taxonomy, and distribution of various species of *Chymomyza* (Diptera: Drosophilidae). *Ann. Ent. Fenn.* 36: 1-9.
- Heed, W. B. 1968. Ecology of the Hawaiian Drosophilidae. Univ. of Texas Publ. No. 68: 387-419.
- Jackson, J. A. and B. J. S. Jackson. 1986. Why do red-cockaded woodpeckers need old trees? *Wildl. Soc. Bull.* 14: 318-322.
- Lachaise, D. 1977. Niche separation of African *Lissocephala* within the *Ficus* Drosophilid community. *Oecologia* 31: 201-214.
- Lachaise, D. and L. Tsacas. 1983. Breeding sites of tropical African Drosophilidae. pp. 221-232 in M. Ashburner, H. L. Carson and J. T. Thompson, Jr. (eds.). *Genetics and Biology of Drosophila*. Vol. 3d. Academic, London.



- Ligon, J. D., P. B. Stacey, R. N. Conner, C. E. Bock and C. S. Adkisson. 1986. Report of the American Ornithologists' Union Committee for the conservation of the Red-cockaded woodpecker. *Auk* 103: 848-855.
- McCoy, C. E. 1962. Population ecology of the common species of *Drosophila* in Indiana. *J. Econ. Entomol.* 55: 978-985
- Oatman, E. R., E. F. Leegner and R. F. Brooks. 1964. An ecological study of arthropod populations on apple in Northeastern Wisconsin: Insect species present. *J. Econ. Entomol.* 57: 978-983.
- O'Brien, M. F. 1987. Biology and distribution of *Tachysphex aethiops* in Michigan (Hymenoptera: Specidae: Larrinae). *Great Lakes Entomol.* 20: 71-80.
- Peden, W. (ed.). 1985. Thomas Jefferson's Notes on the State of Virginia. Univ. of North Carolina Press, Chapel Hill. xxv + 315 pp.
- Ratcliffe, D. 1979. The end of the large blue butterfly. *New Scientist* 83: 457-458.
- Sabath, M. D. and J. M. Jones. 1973. Measurement of niche breadth overlap: the Colwell-Futuyma method. *Ecology* 54: 1143-1147.
- Sieger, M. B. and H. J. Khamis. 1987. A multifactorial behavioral study of coexisting drosophilid species in nature. *Evolution* 41: 209-217.
- Sokal, R. R. and F. J. Rohlf. 1981. Biometry. W. F. Freeman, San Francisco. xviii + 859 pp.
- Steyskal, G. 1952. Letter to Marshall Wheeler (courtesy of Dr. Wheeler).
- Strickberger, M. 1985. Genetics. MacMillan, New York. 868 pp.
- Sturtevant, A. 1921. The North American species of *Drosophila*. *Carne. Inst. Wash.* 302: 1-150.
- Terbough, J. 1986. Keystone plant resources in the tropical forest. pp. 330-344 in M. E. Soule (ed.). *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer, Sunderland, MA.
- Throckmorton, L. H. 1962. The problem of phylogeny in the genus *Drosophila*. *Univ. of Texas Publ. no. 6205*: 207-343.
- . 1975. The phylogeny, ecology and geography of *Drosophila*. pp. 421-469 in R. C. King (ed.). *Handbook of Genetics*. Vol. 3.
- Wallace, B. 1978. The adaptation of *Drosophila virilis* to life on an artificial crab. *Amer. Nat.* 112: 971-973.
- Weatherhead, P. J. 1986. How unusual are unusual events? *Amer. Nat.* 128: 150-154.
- Wheeler, M. R. 1952. The Drosophilidae of the Nearctic region, exclusive of the genus *Drosophila*. *Univ. of Texas Publ. no. 5404*: 162-218.
- . 1965. Family Drosophilidae. pp. 760-772 in *A Catalog of Diptera of North America*. U. S. Dept. of Agriculture, Ag. Res. Serv. Ag. Handbook no. 276.
- Wilcove, D. S., C. H. McLellan and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. pp. 237-256 in M. Soule (ed.). *Conservation Biology: The Science of Scarcity and Diversity*. Sinauer, Sunderland, MA.
- Wyman, D. 1971. *Wyman's Gardening Encyclopedia*. MacMillan, New York. xv + 1222 pp.
- Zimmerman, B. L. and R. D. Bierregaard. 1986. Relevance of the equilibrium theory of island biogeography and species-area relations to conservation with a case from Amazonia. *J. Biogeography* 13: 133-143.

## Forest Composition of the Southern Blue Ridge Escarpment in Virginia

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### ABSTRACT

In 16 slope forest stands between 348 and 922 m in the Virginia Blue Ridge south of the Roanoke Gap, *Quercus prinus* was usually the overwhelming dominant. *Quercus rubra* was next most abundant, and *Q. alba* and *Q. velutina* were important in four stands each. Stands with abundant *Oxydendron arboreum* and *Acer rubrum* separated from each other on a detrended correspondence analysis (DECORANA) ordination, with the first species in slightly more fertile sites and the latter mostly on westerly and southerly slopes. In the sapling layer, *Cornus florida* was the most important species, followed by *A. rubrum* and *O. arboreum*. No present or potential canopy species was reproducing well. These forests lacked the abundant *Carya* reported north of the Roanoke Gap by Johnson and Ware (1982), but had more *Quercus alba*, *Q. velutina*, *Cornus*, and *Acer rubrum*. Our stands did not have the abundant *Q. coccinea* reported (Stephenson 1974) for post-chestnut forests of the Ridge and Valley province of Virginia.

### INTRODUCTION

In their study of old growth forests of the central Blue Ridge of Virginia, north of the Roanoke River Gap, Johnson and Ware (1982) reported far more hickory (*Carya* spp.) and less white oak (*Quercus alba*) and red maple (*Acer rubrum*) than had been reported by Whittaker (1956) for equivalent elevations in the Great Smokies. Since the Roanoke Gap is considered a major ecological breakpoint along the Blue Ridge (Braun 1950), we undertook a study of forest stands along the Blue Ridge escarpment south of the Gap to determine whether forest composition there might resemble more closely the forests of equivalent elevations in the Smokies or Johnson and Ware's (1982) stands north of the Gap. Though Rheinhardt and Ware (1984) have examined mountain forests south of the Roanoke Gap in Virginia, their stands were farther west and generally at higher elevations than the Johnson and Ware (1982) stands, and thus not directly comparable. Our stands were located along an 88 km



length of the Blue Ridge Parkway from Roanoke Mountain south to Mabry Mill (Parkway mileposts 120-175). Like Johnson and Ware (1982), we sampled slope stands covering a range of elevation (348 to 922 m), direction of exposure, and degree of slope. Our study lacked high ( $> 1000$  m) peaks, however, so our highest stands were more than 200 m lower than Johnson and Ware's (1982) highest stands.

## METHODS

Stands sampled in this study lacked saw-cut stumps or frequent breaks in the canopy which might signal recent ( $< 20$  yr) selective cutting, and they had low importance of known post-disturbance invaders like *Robinia pseudo-acacia* and *Pinus* spp. However, all the stands probably were timbered, at least selectively and in most cases perhaps heavily, before the establishment of the Blue Ridge Parkway. An attempt was made to sample at least one stand representing each of four quadrants of the compass within three elevational ranges: 350-600 m, 600-850 m,  $> 850$  m. No samples were taken from southeast-facing slopes between 350 and 850 m, for the few forests we found at that elevation range and exposure had been greatly disturbed. In each stand, four Bitterlich-circular quadrat sample points (Levy and Walker 1971) were placed at 30 m intervals along a compass line placed through the center of the stand along its long axis. At each point, canopy dominance of each species (basal area,  $m^2/ha$  cross-sectional area breast high [1.4 m]) was measured by the Bitterlich method using a Spiegel Relaskop. Density of large trees ( $\geq 10$  cm diameter at breast height [dbh]) was determined at each point by counting and recording for each species all such stems within a 10 m diameter circle centered on the point. Density of saplings was based on a count at each point of all stems 2.5 to 10 cm dbh within a 5 m radius circle centered on the point. Relative dominance and relative density for large trees were calculated for each stand and averaged to yield a relative importance value (I.V.) for each species in the large tree category in each stand (Johnson and Ware 1982). From these an ordination was derived using detrended correspondence analysis (DECORANA) of the Cornell Ecology Program Series (Hill and Gaugh 1980). Importance of species in the sapling category is expressed by calculated relative densities for each species in that size category in each stand. Taxonomic nomenclature follows Harvell, *et. al.* (1986).

Elevation and degree of slope were recorded at each sample point within the stand and were averaged for each stand. Soil samples to a depth of 10 cm were taken from at least three sample points within each stand, mixed thoroughly, and sent to the Soil Testing Laboratory of the V.P.I. & S.U. Cooperative Extension service for pH and mineral analysis. Soil mineral content in ppm was determined for oxides of Ca, Mg, P, and K. Rank correlation tests and Chi square tests were used where appropriate to test for relationships between species abundances and measured environmental variables (Scheffler 1979). We thank the National Park Service for permission to take soil samples.



Table 1. The number of times each species was ranked as one of the top three species, the number of stands where the species was found, and the highest I.V. attained for each species. Only species ranking third or reaching I.V.  $\geq 10$  in at least one stand are included.

Species	number of times ranked			Number I.V. $\geq 10$	Presence (out of 16)	Highest I.V. obtained
	1	2	3			
<i>Quercus prinus</i>	1	2	1	14	16	56.2
<i>Quercus rubra</i>	2	6	3	9	16	42.6
<i>Quercus alba</i>	1	1	3	4	13	46.4
<i>Liriodendron tulipifera</i>	1	1	0	2	11	63.1
<i>Pinus rigida</i>	1	0	0	1	2	41.3
<i>Acer rubrum</i>	0	3	3	5	15	23.5
<i>Quercus velutina</i>	0	2	1	3	11	32.9
<i>Oxydendron arboreum</i>	0	1	2	3	8	20.9
<i>Quercus coccinea</i>	0	1	0	1	9	10.3
<i>Betula alleghaniensis</i>	0	0	1	1	7	14.0
<i>Cornus florida</i>	0	0	1	0	7	8.8
<i>Carya glabra</i>	0	0	1	2	5	17.5
<i>Nyssa sylvatica</i>	0	0	0	1	13	10.3
<i>Carya ovalis</i>	0	0	0	1	8	7.5

## RESULTS

Thirty-two species were recorded in the sampled stands. The area was overwhelmingly dominated by chestnut oak (*Quercus prinus*), which appeared as a major canopy species at all elevations and exposures (Table 1). It was found at all 16 stands, reached an I.V.  $\geq 15$  in 14 stands, (all except A and L of Fig. 1), and was the leading dominant in 11 stands. Its average I.V. was 31.9. Chestnut oak demonstrated a broad tolerance to measured soil factors. It had an I.V. 50 both at stand C, where K, P, Ca, and Mg values are highest, and at stand H, which had very low K, P, Ca, and Mg levels (Table 2).

Northern red oak (*Quercus rubra*) also appeared in all of the sampled stands, with an average I.V. of 16.3. It achieved its highest I.V. value (42.6) at stand L. While stands rich in chestnut oak occurred broadly across the ordination, high values of northern red oak are concentrated in the lower left part of the ordination (Fig. 1). This distribution pattern can not be related to any of the measured environmental variables.

White oak (*Quercus alba*) was present in 13 of the 16 sampled stands, but all stands with high I.V. occurred to the right on the ordination (Fig. 1). Still, since the four stands where its I.V.  $\geq 10$  include two stands where northern red oak I.V.  $\geq 20$  (A and H), white oak can hardly be said to dissociate from that species. All four white oak stands have westerly or southwesterly exposures, (NW, WSW, SW, SSW) but no other measured environmental factor can be related to the distribution of white oak.

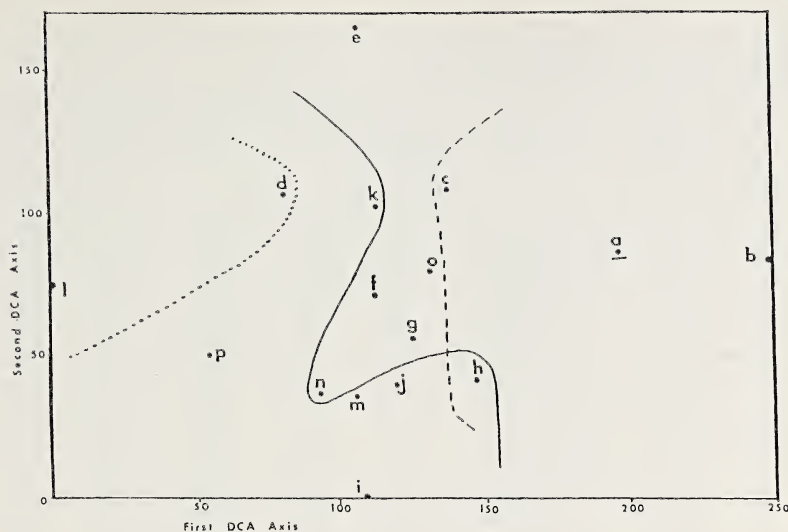


FIGURE 1. A DECORANA ordination of the 16 stands (a-m) based on tree I.V. Stands left of the dotted line have *Carya* spp. I.V.  $> 10$ ; stands to the left of the solid line have *Quercus rubra* I.V.  $\geq 10$ , with stand a an outlier; and stands to the right of the dashed line have *Q. alba* I.V.  $\geq 10$ .

On the Y axis of the ordination (Fig. 2) stands with higher red maple (*Acer rubrum*) I.V. separate from those with higher I.V. of sourwood (*Oxydendron arboreum*) and (with one overlap) black oak (*Quercus velutina*). The five stands in which black oak and sourwood are important have the five highest values for Mg, four of the five highest values for Ca and for P, and three of the five highest values for K. In contrast, the five stands in addition to F (shared with black oak) where red maple was important rarely had soil mineral values above the median for all stands. All but one of the stands with high red maple I.V. were westerly or southerly facing. No other measured variables could be related to the distribution of these three species.

While occurring in 11 stands, tuliptree (*Liriodendron tulipifera*) was important in only two stands, located on the far left on the ordination (Fig. 2). Northern red oak was the other major species in these stands. Stand P, on a sheltered slope above a stream and perhaps the most moist stand we sampled, also had yellow birch (*B. alleghaniensis*) with I.V. = 14, the only place this species became important.

Hickories (*Carya* spp.) were found in 13 stands, but a hickory species reached an I.V.  $\geq 10$  in only 2 stands: *Carya glabra* in stands L and D and *C. ovalis* also in stand D, though the latter species occurred at low levels broadly across the ordination (Fig. 1). *Carya ovata* was present at low levels in the three stands on the far left of the ordination and *C. tomentosa* was present in five stands scattered in the left center of the ordination. Combined *Carya* spp. I.V. reached 9.9 in stand E. The only other tree species to reach an I.V.  $\geq 10$  in any stand were pitch pine (*Pinus rigida*) in stand B, scarlet oak (*Quercus coccinea*) in stand O, and black gum (*Nyssa sylvatica*) in stand D, though the last species occurred at low I.V. in 13 of 16 stands.

Table 2. Characteristics of Sampled Stands

Stand	Elevation (meters)	direction of exposure	degree of Slope (%)	pH	Ca	Mg (in ppm of oxides)	K	P
a	722	247° (WSW)	8	5.1	588	77	72	3
b	392	304 (WNW)	25	4.5	96	25	53	2
c	453	217 (SW)	37	4.6	924	120	155	11
d	386	11 (NNE)	28	5.1	288	79	64	5
e	738	80 (ENE)	24	5.4	588	120	74	2
f	881	251 (WSW)	21	5.2	324	92	63	7
g	658	307 (WNW)	18	4.4	240	38	72	5
h	658	202 (SSW)	23	4.6	84	23	44	3
i	658	285 (WNW)	8	3.7	132	48	64	3
j	762	360 (N)	13	5.0	240	53	53	3
k	881	185 (SSW)	18	4.0	348	77	106	6
l	905	98 (ESE)	68	4.8	192	43	75	4
m	922	302 (NNW)	23	-	-	-	-	-
n	660	180 (S)	30	4.8	108	31	58	1
o	878	191 (SSW)	20	4.3	204	53	77	3
p	348	48 (NE)	33	4.8	240	47	31	3

In the sapling category, dogwood (*Cornus florida*) was the most important species, occurring in ten stands. However, it was unimportant or absent from those stands (in the lower center of the ordination) where red maple was the major sapling species. Red maple was important in the sapling category in more stands than in the tree category, but the stands with the highest sapling relative densities were in the same portion of the ordination (Fig. 2) as those with high I.V. in the tree category. All stands in the high red maple sapling relative density were westerly or southerly facing, just as were five of the six stands where red maple was important in the tree size class. Sourwood likewise was important in more stands as a sapling than as a tree, but had higher sapling values in the same portion of the ordination (Fig 2) where sourwood was important in the tree category.

American chestnut (*Castanea dentata*) root sprouts were present in the sapling sample plots in three stands and were observed outside the sample plots in six additional stands. Chestnut oak, northern red oak, and black oak occurred in the sapling category very rarely, and at low abundances when present. There were no white oak saplings at all. Hickories (*Carya* spp) appeared sporadically and with very low abundance in the sapling class. Dogwood, red maple, and sourwood were the only species commonly present in the sapling layer. No present or potential canopy species was reproducing well.



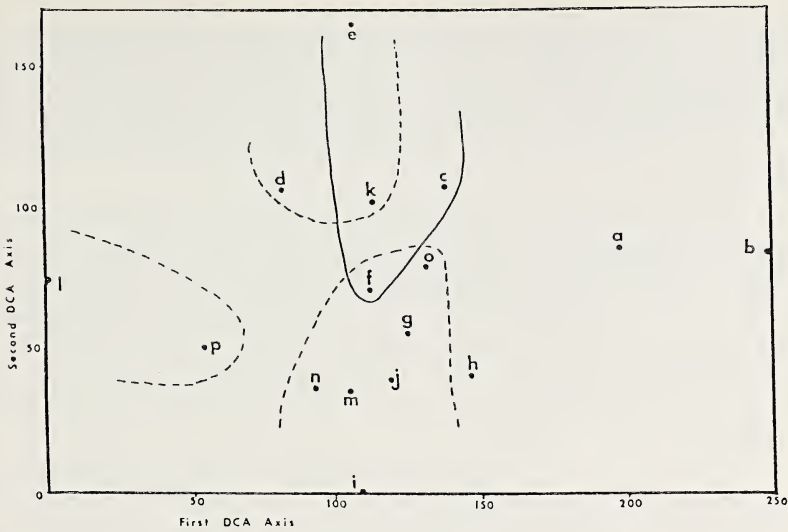


FIGURE 2. Ordination as in Fig. 1. The left dashed line encloses stands with *Liriodendron tulipifera* I.V.  $\geq 10$ ; the upper dashed line encloses stands where *Oxydendron arboreum* I.V.  $\geq 10$ ; the solid line encloses stands where *Quercus velutina* I.V.  $\geq 9$ ; and the lower dashed line encloses all stands where *Acer rubrum* I.V.  $\geq 9$ , with stand m an exception.

### DISCUSSION

The low importance of northern red oak, and the poor correlation of chestnut oak abundance with aspect may be related to the lower elevation in our area as compared to Johnson and Ware (1982) and Stephenson (1974). Those studies reported northern red oak to be more important at higher elevations, and the displacement of chestnut oak to southerly sites at those higher elevations. However, our range of elevations is within the lower zone where Johnson and Ware (1982) found chestnut oak to dominate in all but the most mesic situations.

Braun (1950) listed white oak as an important canopy species of the northern Blue Ridge of Virginia, and Whittaker (1956) reported it to be "strongly dominant on some exposed southwest ridges" at high elevations ( $> 1390$  m) in the Smokies. McCormick and Platt (1980) and Adams and Stephenson (1983) also found white oak to be important on higher southerly and southwesterly slopes. However, Johnson and Ware (1982) did not find white oak to be of great importance in the central Blue Ridge of Virginia, but did suggest that it might be more important in the mountains south of the Roanoke Gap. White oak achieved its highest importance in our study on westerly slopes between 400 and 650 m. This abundance of white oak confirms that, despite its low abundance in the central Blue Ridge, white oak can be an important canopy species along the eastern escarpment of the southern Blue Ridge. Like Johnson and Ware (1982), we can offer no explanation for the greater importance of white oak south of the Roanoke Gap as compared to their Peaks of Otter study area.

Black oak was more abundant in our section of the Blue Ridge than noted by Braun (1950) for the northern section or by Johnson and Ware (1982) for the central section. Braun (1950) suggested that black oak and scarlet oak were

more abundant in drier oak-hickory forests, as did Stephenson (1974). In our study, three of the highest black oak I.V.'s were on WSW to SSW slopes, but the highest I.V. was on an east slope. Four of the top scarlet oak I.V.'s were on WSW to SSW slopes, but the second highest I.V. was on an east slope. Scarlet oak was not important even where it was most abundant; only once did its I.V. reach 10.

Keever (1953) predicted that the loss of chestnut in the wake of the chestnut blight would open the canopy for hickories to replace chestnut as a canopy species, and McCormick and Platt (1980) and Stephenson (1982) found this in Giles Co., VA. Johnson and Ware (1982) found hickory to be abundant and structurally important in the mountains north of the Roanoke Gap, but noted their impression, which our study confirms, that hickories were neither important nor widespread south of the Roanoke Gap. The reason for this difference is unclear.

Unlike Johnson and Ware (1982), we found red maple to be an important canopy and understory species in many of our stands. Our findings are consistent with those of Braun (1950) and Whittaker (1956) who found red maple to be "fairly important at all but the most mesic coves and driest ridges." Though Johnson and Ware (1982) did not sample the sapling layer, they noted that dogwood (*Cornus florida*) did not seem to be important in their area. In contrast, we found it to be the most important understory species. Even so, the absolute densities of dogwood were quite low compared with densities found by Monette and Ware (1983) in the Virginia Coastal Plain.

Like Johnson and Ware (1982), we found old fallen American chestnut logs as well as chestnut saplings in abundance throughout the study area, confirming that most of our stands were formerly oak-chestnut forests. In three cases, chestnut sapling were large enough ( $> 2.5$  cm dbh) to be counted in our understory plots, resulting in a relative density  $> 20$  in two of these stands. In these, chestnut was the second most important understory species.

Based on tree size and age, many of the stands sampled by Johnson and Ware (1982) apparently had not been greatly disturbed except for the removal of dead chestnut trees from some stands. Judging by tree sizes in most of our stands, all but a few of our stands were second growth forest. This difference in stand history may explain some of the differences in understory and overstory composition of their stands versus ours, though we are unable to verify this.

Timbering history may explain in part the differences in stem density in their and our studies. Only four of their 16 stands had more than 350 tree-sized ( $> 10$  cm dbh) stems/ha; 15 of our 16 had greater densities. Yet, total basal areas from both studies are quite comparable. Thus, we had more but smaller trees, which would be expected in younger (more recently timbered) forests. Our average density was 529 trees/ha. Stephenson (1974) reported 757 trees/ha on south slopes and 810 trees/ha on north slopes, and Adams and Stephenson (1983) reported 832 trees/ha, so both Blue Ridge studies show much lower densities than the Ridge and Valley and Alleghany Mountain Provinces.

Our small tree ( $> 10$  cm,  $\geq 2.5$  cm dbh) densities ranged from 339 to 1337 stems/ha, with an average of 715, less than half the average reported by Adams and Stephenson (1983) for that size class. Our low total density may be related to poor reproduction of canopy species. Perhaps the most startling finding of our study is this failure of any present or potential canopy trees to have sizable

numbers of saplings. Dogwood, chestnut, sourwood, and red maple are all unlikely to become canopy dominants because of various genetic and environmental limitations. Thus, it becomes impossible to extrapolate from our sapling data to future canopy composition of these forests.

## LITERATURE CITED

- Adams, H.S., and S.L. Stephenson. 1983. A description of the vegetation of the south slopes of Peters Mountain, southwestern Virginia. *Bull. Torrey Botan. Club* 110:18-22.
- Braun, E. Lucy. 1950. *Deciduous forests of Eastern North America*. The Blakiston Co., Phila. 595 pp.
- Harvill, A. M. Jr., T. R. Bradley, C. E. Stevens, T. F. Wieboldt, D. M. E. Ware, and D. W. Ogle. 1986. *Atlas of the Virginia Flora*. 2nd ed. Virginia Botanical Associates. Farmville, VA. 135 p.
- Hill, M.O. and H.G. Gaugh, Jr. 1980. Detrended correspondence analysis: an improved ordination technique. *Vegetatio* 42:329-343.
- Johnson, G.G. and S. Ware. 1982. Post-chestnut forests in the central Blue Ridge of Virginia. *Castanea* 47:329-343.
- Keever, C. 1953. Present composition of some stands of the former oak-chestnut forest in the southern Blue Ridge Mountains. *Ecology* 34:44-54.
- Levy, G.F. and S.W. Walker. 1971. The combined Bitterlich rangefinder-circular-quadrant method in phytosociological studies. *Jeffersonia* 5:37-39.
- McCormick, J.F. and R.B. Platt. 1980. Recovery of an Appalachian forest following the chestnut blight, or Catherine Keever, you were right! *Amer. Midland Nat.* 104:265-273.
- Monette, R. and S. Ware. 1983. Early forest succession in the Virginia Coastal Plain. *Bull. Torrey Botan. Club* 110:80-86.
- Rheinhardt, R.D. and S. Ware. 1984. The vegetation of the Balsam Mountains of southwest Virginia: a phytosociological study. *Bull. Torrey Botan. Club* 111:287-300.
- Scheffler, W. C. 1979. *Statistics for the biological sciences*. Addison-Wesley Publ. Co., Reading, MA. 277 p.
- Stephenson, S.L. 1974. Ecological composition of some former oak-chestnut communities in western Virginia. *Castanea* 39:278-286.
- Stephenson, S.L. 1982. Exposure-induced differences in the vegetation, soils, and microclimate of north- and south-facing slopes in southwestern Virginia. *Va. J. Science* 33:36-50.
- Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains. *Ecol. Monogr.* 26:1-80.



## **Plasma Concentrations of Thyroxine and Triiodothyronine in Beef Steers Fed Trichlorophenol**

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### **ABSTRACT**

Two experiments were conducted to gain evidence as to whether 2,4,5-trichlorophenol (TCP), a metabolite of the systemic pesticide ronnel, affects thyroid function. Exp. 1 consisted of two trials. In trial 1, six growing beef steers (2 per treatment) were fed the same basal diet and orally dosed by feeding with the diet either no chemical, 2 mg propylthiouracil (PTU; a known inhibitor of thyroid function) or 4 mg TCP per kg body weight daily. In trial 2, the same six steers were treated with no chemical (1 steer), 1 mg TCP (2 steers), 2 mg TCP (2 steers) or 4 mg TCP per Kg bodyweight daily (1 steer). Blood samples were collected up to 23 d in both trials for measurement of plasma concentrations of thyroid hormones. In Exp. 2, eight steers were treated with four levels of TCP (0, 1.0, 2.0 and 4.0 mg TCP per kg body weight daily). The steers were rotated among TCP levels for five 3-wk periods in a Latin-square design. Blood samples were collected up to 21 d for plasma thyroid hormone analysis. In Exp. 1, plasma T<sub>4</sub> and the ratio of T<sub>4</sub> to T<sub>3</sub> were similar to those of nontreated steers when 1 mg TCP was fed, but appeared increased with 2 mg TCP and decreased with 4 mg TCP. Exp. 2, however, did not indicate a difference in the T<sub>4</sub> concentrations or in the ratio of T<sub>4</sub> to T<sub>3</sub> among the various levels of TCP fed. These results suggest that the ronnel metabolite 2,4,5-trichlorophenol did not affect thyroid function under the conditions of this study.

## INTRODUCTION

The organophosphate ronnel [O,O-dimethyl O-(2,4,5-trichlorophenyl) phosphorothioate], a chemical used in the past as a systemic pesticide in cattle, has been shown to increase growth rate and feed conversion of beef cattle approximately 12% (Rumsey, 1979). Further study has shown that this chemical affects thyroid function as evidenced by an increase (30%) in plasma thyroxine (T<sub>4</sub>) concentration and a slight decrease in plasma triiodothyronine (T<sub>3</sub>) concentration (Rumsey *et al.*, 1983). The effects of ronnel on plasma concentrations of T<sub>4</sub> and T<sub>3</sub> are similar to effects of the thyroid inhibitor propylthiouracil (PTU) in beef steers (Rumsey *et al.*, 1985) and suggest a dose dependent change in peripheral T<sub>4</sub> metabolism. Studies by Escobar del Ray and Morreale de Escobar (1961) and Morreale de Escobar and Escobar del Rey (1962) have shown similar changes in circulating T<sub>4</sub> and T<sub>3</sub> concentrations to be related to peripheral monodeiodinase inhibition in rats treated with PTU. Ronnel has recently been shown to directly inhibit the conversion of T<sub>4</sub> to T<sub>3</sub> in liver and kidney tissue of cattle (Kahl *et al.*, 1985). Thus, changes in peripheral thyroxine metabolism may be an important part of the mechanism by which ronnel improves growth rate and feed conversion.

Ronnel is no longer manufactured; thus, studies using this chemical as a model for influencing growth are not possible. However, ronnel is readily metabolized in the animal although it is not known if the observed effects of ronnel on animal growth and thyroid function are caused directly by ronnel or indirectly by a metabolite of ronnel. A major metabolite of ronnel is 2,4,5-trichlorophenol (TCP; Plapp and Casida, 1958) which is toxic to animals. In this study, *in vivo* trials were designed to investigate the possibility of an indirect effect of ronnel by determining if the metabolite TCP causes changes in plasma T<sub>4</sub> and T<sub>3</sub> concentrations.

## EXPERIMENTAL PROCEDURE

EXP. 1. This experiment, reported in abstract form by Ward *et al.* (1984), consisted of two trials designed to gain preliminary information on the effect of TCP and to determine the approximate effective dose. Trial 1 consisted of six Hereford steers (avg wt 270 kg) where two of the six received no chemical treatment and served as controls, two steers received 2 mg PTU/kg body weight daily and two steers received 4 mg TCP/kg body weight daily. The effect of ronnel and PTU on plasma T<sub>4</sub> and T<sub>3</sub> concentrations has been shown to be similar and the TCP dose approximated the effective dose of ronnel (Rumsey *et al.*, 1983). The steers received their respective daily chemical treatments in a cornstarch premix at the morning feeding for a period of 23 d.

The steers were housed individually in indoor pens with outside runs, had *ad libitum* access to water and were fed the same basal diet at 1.8% of body weight. The basal diet was a mixture of (percentage, as fed) ground hay, 30 (equal amounts of alfalfa and timothy); cracked corn, 50; soybean meal (minimum 44% crude protein), 10; molasses, 7; trace mineral salt, 1; and vitamin A

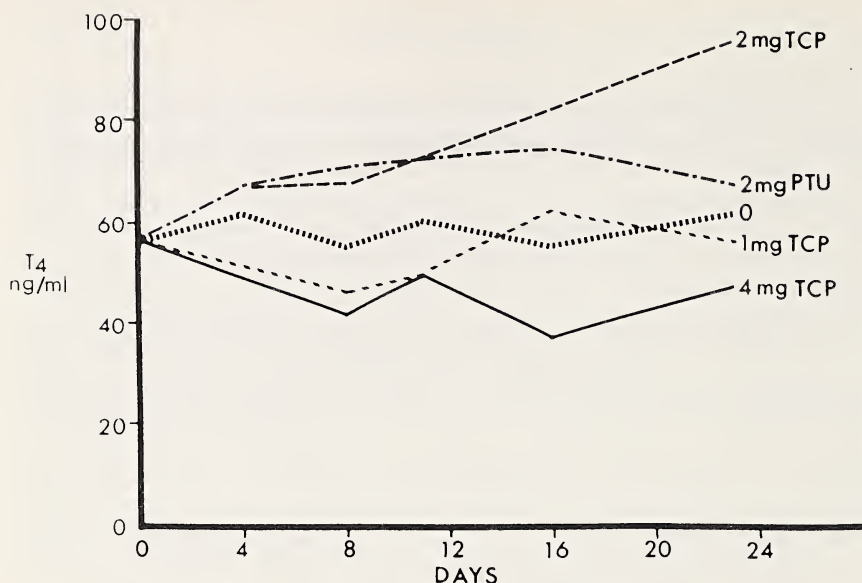


FIGURE 1. Plasma thyroxine (T<sub>4</sub>) concentrations in control steers, steers fed 2 mg propylthiouracil (PTU) per kg body weight daily and steers fed either 1, 2 or 4 mg 2,4,5-trichlorophenol (TCP per kg body weight daily from 0 to 23 days. Each point within a treatment is the mean of 3, 2, 2, 4 and 3 steers for control, 1 mg TCP, 2 mg PTU, 2 mg TCP and 4 mg TCP, respectively.

added at the rate of 2,990 IU/kg of diet. The steers were fed half of their daily dietary allotment at 0800 h and half at 1600 h. There were no orts in this trial and the steers were weighed weekly.

The steers were adapted to the basal diet for at least 3 wk before the treatment started. Samples of venous blood were obtained by jugular venipuncture about 5 h postprandial from each steer before treatment started, at 1, 2, 4 and 8 h after initial feeding of chemical and single samples 5 h postprandial on d 2, 4, 7, 11, 16 and 23 after treatment started. Plasma was harvested following centrifugation and frozen until assayed. Plasma concentrations of T<sub>4</sub> and T<sub>3</sub> were determined on duplicate aliquots by radioimmunoassay using solid phase <sup>125</sup>I RIA kits (IMMUCHEM Corp. Carson, CA 90746) as described by Kahl *et al.* (1978).

Trial 2 used the same steers as used in trial 1. The steers were maintained on the same control diet for 4 wk before treatments were initiated. After this time, one steer (previously a control) was fed no chemical, two steers were fed 1 mg TCP/kg body weight daily, two steers were fed 2 mg TCP/kg body weight and one steer was fed 4 mg TCP/kg body weight. The steers were housed and managed the same as in trial 1 and single jugular plasma samples were obtained 0, 4, 8, 11, 16 and 23 d after treatment started.

For ease of summarizing the data in graphic form, data for the trials were combined (Figures 1 and 2); 3 steers as controls, 2 steers fed 1 mg TCP, 2 steers fed 2 mg PTU, 2 steers fed 2 mg TCP and 3 steers fed 4 mg TCP. The data for



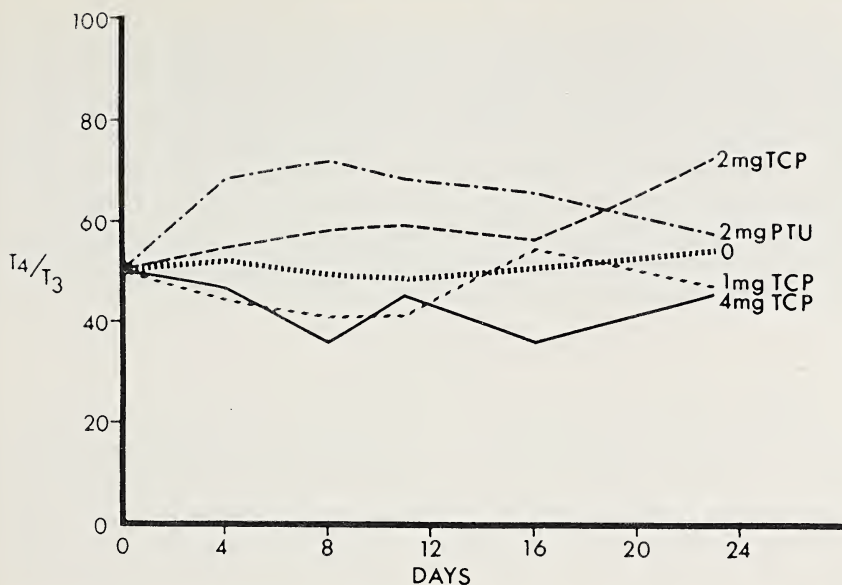


FIGURE 2. Ratio of plasma thyroxine (T<sub>4</sub>) concentration to plasma triiodothyronine (T<sub>3</sub>) concentration in control steers, steers fed 2 mg propylthiouracil (PTU) per kg body weight daily and steers fed either 1,2 or 4 mg 2,4,5-trichlorophenol (TCP) per kg body weight daily from 0 to 23 days. Each point within a treatment is the mean of 3, 2, 2, 4 and 3 steers for control, 1 mg TCP, 2 mg PTU, 2 mg TCP and 4 mg TCP, respectively.

each steer across trials were adjusted to equalize the 0-d values in order to remove relative variation across steers at zero time. The influence of treatment was tested by analysis of variance and Duncan's multiple range test (Steel and Torrie, 1960) using the time means for days 4 through 23 (5 times/mean/steer).

EXP. 2. In a more balanced experiment, reported in abstract form by Hartmann *et al.* (1985), eight Hereford steers (avg wt 325 kg) were used to further assess the effects of TCP on circulating plasma T<sub>4</sub> and T<sub>3</sub> concentrations. Four levels of TCP were fed (0, 1.0, 2.0 and 4.0 mg TCP per kg body weight). Two steers at each treatment level received the TCP in pure form once daily in their diet as in Exp. 1. The steers were fed their respective treatments (following a 2-wk adaptation to the same diet) for 21 d and then rotated among the TCP levels for four additional 21-d periods in a Latin Square design. Plasma samples were obtained 5 h postprandial once daily on d 0, 1, 3, 5, 7, 9, 15 and 21 of each treatment period. Animal management and hormone analyses were the same as in Exp. 1.

This experiment was patterned after an experiment reported for ronnell (Rumsey *et al.*, 1983). Treatment assignments for the first and fifth periods were the same, and the treatment rotation during the trial was such that steers fed the lower TCP levels (0 and 1 mg) always were switched to the higher levels (2 and 4 mg, respectively) and steers fed the higher levels (2 and 4 mg) always were switched to the lower levels (0 and 1 mg, respectively). Day 21 served as 0 d for the next period.

Plasma data for each treatment within period 1 were adjusted to the same 0-d concentrations and evaluated separately from the data for periods 2 through 5 by analysis of variance as a split-plot-in-days with level of TCP as the main effect. Plasma data for periods 2 through 5 were similarly evaluated as a Latin square split-plot-in-days. Also, the concentrations of T<sub>4</sub> and T<sub>3</sub> at 15 and 21 d were averaged for each treatment within all periods. These averages for all periods were evaluated as an extra period Latin square with level of TCP and period as the main effects and by Duncan's new multiple range test after obtaining a significant F test (Steel and Torrie, 1960).

## RESULTS

EXP. 1. In trial 1, plasma T<sub>4</sub> concentrations in steers decreased in response to the 4 mg TCP, while the plasma T<sub>4</sub> concentrations increased in response to the PTU treatment (Figure 1). The response to the PTU was as expected from previous experiments, but the TCP response was not expected. This decrease in plasma T<sub>4</sub> concentration in response to TCP was believed to be due to an adverse effect similar to that observed when high levels of PTU (4 mg/kg body weight) are fed, indicative of a direct inhibition of the thyroid gland (Morreale de Escobar and Escobar del Rey, 1962). In previous trials (Rumsey, 1983), ronnel also appeared to be thyroid depressing at high dose levels. Thus, this first trial indicated TCP may affect thyroid function and a second trial was conducted in which lower levels of TCP were fed to the same six steers.

In trial 2, steers fed 2 mg TCP per kg body weight showed increased concentrations of plasma T<sub>4</sub> (Figure 1). The 1 mg level of TCP appeared to show an initial decrease in T<sub>4</sub> concentration but with time, remained similar to the controls. The 4-mg level was consistent with the first trial in showing a decrease in peripheral T<sub>4</sub> concentrations.

The treatment means for d 4 through 23 were 58.2 ng/ml for control, 69.9 for PTU, 52.6 for 1 mg TCP, 76.5 for 2 mg TCP and 44.8 for 4 mg TCP. Together, the treatment means for PTU and 2 mg TCP were similar to each other and greater (P.05) than the other treatments. Treatment means for the control and for 1 mg TCP were similar; and that for 4 mg TCP was lowest (P.05). Standard error of the mean was 3.0 ng/ml.

The T<sub>3</sub> data were used to calculate the T<sub>4</sub> to T<sub>3</sub> ratio. Shown in Figure 2, they indicate an overall increase in the T<sub>4</sub> to T<sub>3</sub> ratio when 2 mg TCP or 2 mg PTU were fed. The treatment means for the T<sub>4</sub> to T<sub>3</sub> ratio for d 4 through 23 were 50.6 for control, 65.9 for PTU, 45.3 for 1 mg TCP, 60.2 for 2 mg TCP and 42.3 for 4 mg TCP. Statistical differences between means were similar to those for T<sub>4</sub> concentration. Standard error of the mean was 2.4 ng/ml.

EXP. 2. Results of the effect of TCP treatment on plasma concentrations of T<sub>4</sub> and T<sub>3</sub> for the initial period when none of the steers had previously been fed TCP are shown in Figure 3. The time by treatment interaction for T<sub>4</sub> and T<sub>3</sub> in period 1 was not significant. Results for periods 2 through 5 are shown in Figure 4. There was no effect of TCP treatment during these periods. As in previous studies with ronnel (Rumsey *et al.*, 1983) and PTU (Rumsey *et al.*,

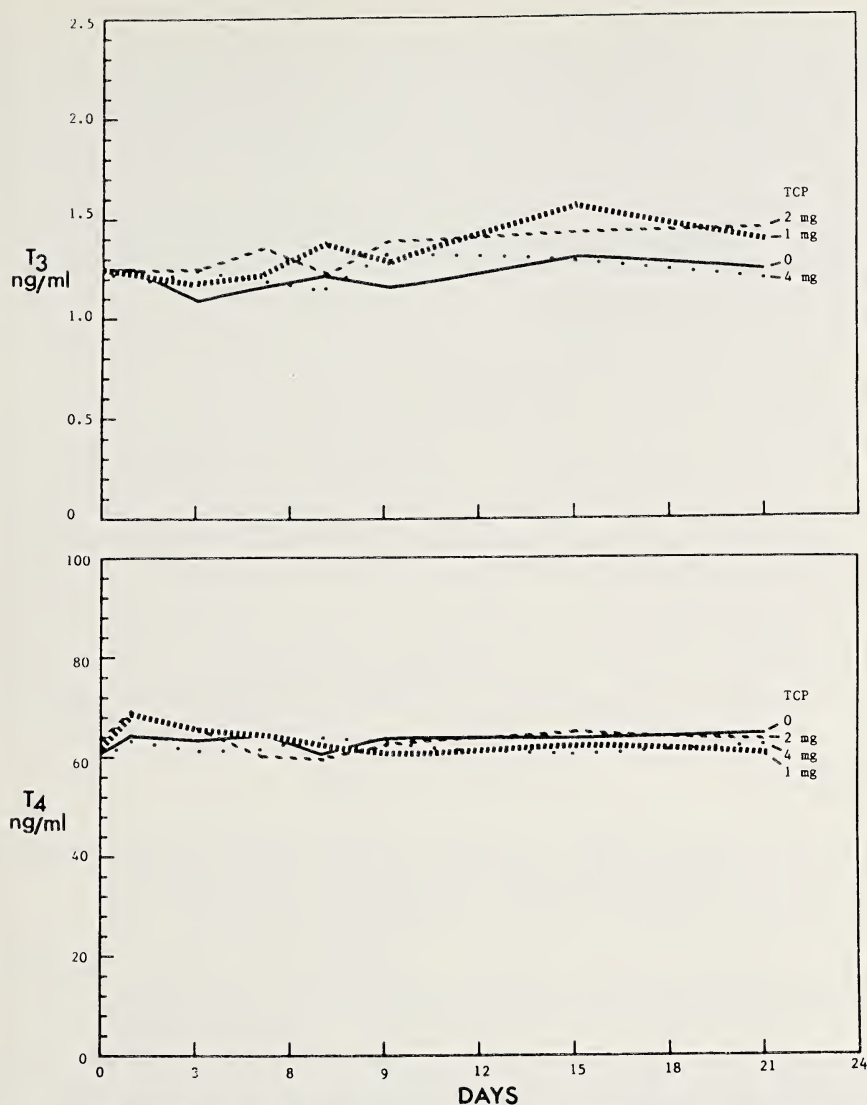


FIGURE 3. Plasma thyroxine ( $T_4$ ) and triiodothyronine ( $T_3$ ) concentrations in beef steers after the initial feeding of 0, 1, 2, or 4 mg 2,4,5-trichlorophenol (TCP)/kg body wt daily. Data are from period 1 of Exp. 2 and represent two animals/treatment, thus each treatment  $\times$  day mean is derived from two measurements. The TCP treatment  $\times$  day SE for  $T_4$  was 5.19 ng/ml and for  $T_3$  was .14 ng/ml.

1985), results from the latter days of blood sampling in each period were averaged to better estimate the long-term shift in  $T_4$  and  $T_3$  concentrations due to treatment. The  $T_4$  treatment means for d 15 and 21 during periods 1 through 5 in the current study were 63.9 ng/ml for control, 62.4 for 1 mg/ml TCP, 63.6 for 2 mg TCP and 59.9 for 4 mg TCP. The means for the  $T_4$  to  $T_3$  ratio were



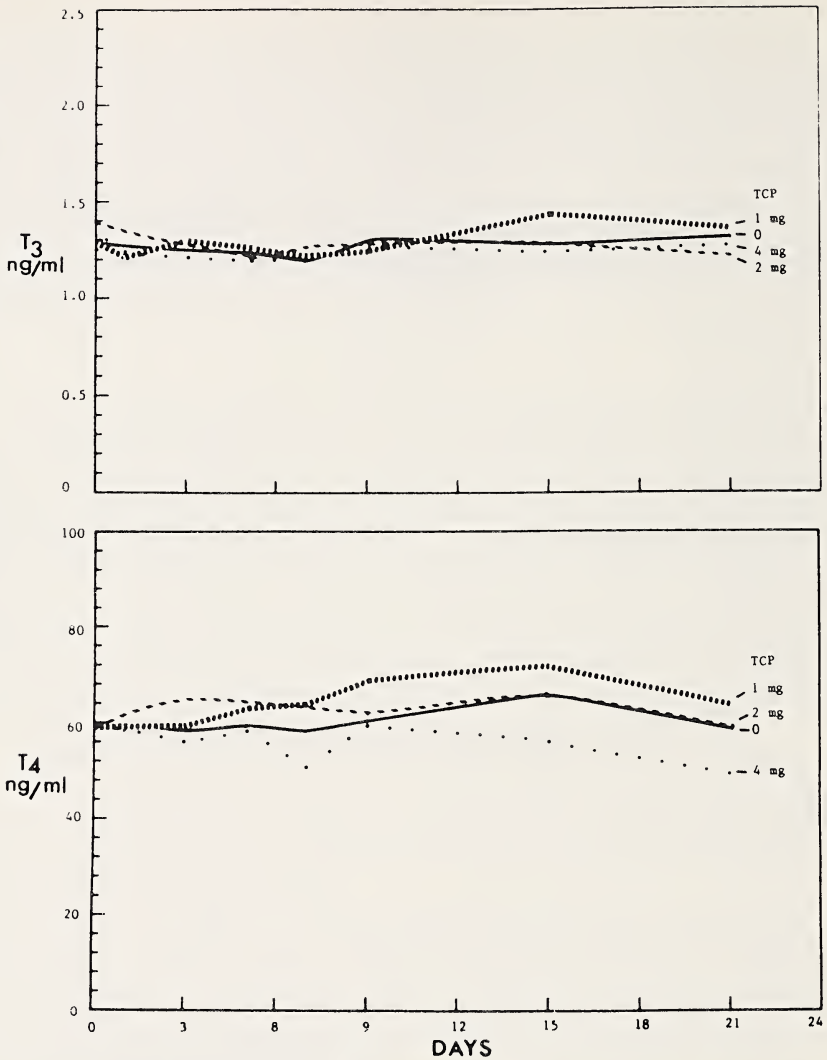


FIGURE 4. Plasma thyroxine (T<sub>4</sub>) and triiodothyronine (T<sub>3</sub>) concentrations in beef steers after the initial feeding of 0, 1, 2, or 4 mg 2,4,5-trichlorophenol (TCP)/kg body wt daily. Data are from period 2 through 5 of Exp. 2 and represent two animals/treatment, thus each treatment x day mean is derived from eight measurements. The TCP treatment x day SE for T<sub>4</sub> was 2.28 ng/ml and for T<sub>3</sub> was .06 ng/ml.

50.8 for control, 44.9 for 1 mg/ml TCP, 50.3 for 2 mg/ml TCP and 48.2 for 4 mg/ml TCP. These values did not differ statistically.

### DISCUSSION

Ronnel has been shown, in previous experiments, to have a direct effect on T<sub>4</sub> and T<sub>3</sub> concentrations and thyroid function. As with PTU fed at low levels,

ronnel showed an inhibition of the deiodination of  $T_4$  to  $T_3$  and resulted in an increase in plasma  $T_4$  concentrations and a decrease in plasma  $T_3$  concentrations. Deiodinase inhibition may influence weight gain in cattle (Rumsey, 1985). Whether this effect of ronnel was a direct effect of ronnel per se or an indirect effect of a metabolite was not studied previously. The results of the first experiment suggested that TCP caused changes in  $T_4$  and  $T_3$  concentrations. Although trial 1 of Exp. 1 was not effective in demonstrating an effect of TCP consistent with that of ronnel (elevated  $T_4$  concentrations in plasma), trial 2 at lower levels of TCP, did show an increase in  $T_4$  concentration and an apparent increase in the  $T_4:T_3$  ratio. However, Exp. 1 represented preliminary comparisons of few steers and did not account for long term exposure to TCP.

Exp. 2 was a more balanced design patterned after that used in previous study (Rumsey et al., 1983), and accounted for long term exposure and the effects of increasing and decreasing TCP dose in the same animal. This experiment did not show the clear treatment effects on plasma  $T_4$  and  $T_3$  concentrations as was shown for ronnel in a previous study. This indicates that the ronnel metabolite TCP is not a causative factor in altered  $T_4$  and  $T_3$  concentrations in beef steers treated with ronnel. The summary of results from d 15 and 21 indicated no long term effect of TCP. A slight reduction in both  $T_3$  and  $T_4$  suggested a direct effect on the thyroid gland, but again this was not significant. Thus the results of these experiments indicate that the ronnel metabolite 2,4,5-trichlorophenol does not affect thyroid function as has been shown for ronnel and propylthiouracil.

#### LITERATURE CITED

- Escobar del Rey, F. and B. Morreale de Escobar. 1961. The effect of propylthiouracil, methylthiouracil and thiouracil on the peripheral metabolism of l-thyroxine and thyroidectomized, 1-thyroxine maintained rates. *Endocrinol.* 69:456-465
- Hartmann, Sabine B., T. S. Rumsey, A. S. Kozak, and K. P. Bovard. 1985. Gradient levels of trichlorophenol in beef steers: A follow-up. *Va. J. Sci.* 36:88. (Abstr.).
- Kahl, S., J. Bitman and T. S. Rumsey. 1985. In vitro studies of the effect of propylthiouracil and ronnel on thyroxine-5'-monodeiodinase activity in steers. *J. Anim. Sci.* 61:197-202.
- Kahl, S., J. Bitman and T. S. Rumsey. 1978. Effect of Synovex-S on growth rate and plasma thyroid hormone concentrations in beef cattle. *J. Anim. Sci.* 46:232-237.
- Morreale de Escobar, B. and F. Escobar del Rey. 1962. Influence of thiourea, potassium perchlorate and thiocyanate and of graded doses of propylthiouracil on thyroid hormone metabolism in thyroidectomized rats, isotopically equilibrated with varying doses of exogenous hormone. *Endocrinol.* 71:906-913.

- Plapp, F. W. and J. E. Casida. 1958. Bovine metabolism of organophosphorus insecticides. Metabolic fate of 0,0-dimethyl 0-(2,4,5-trichlorophenyl) phosphorothioate in rats and a cow. *J. Agr. Food Chem.* 6:662-667.
- Rumsey, T. S. 1979. Performance, ruminal measurement and blood plasma amino acids of steers fed ronnel. *J. Anim. Sci.* 49:1059-1065.
- Rumsey, T. S. 1985. Chemicals for regulating animal growth and production. In: (J. L. Hilton Ed.) *Agricultural Chemicals of the Future (BARC Symposium 8)*. Pages 91-108. Rowman and Allanheld, Totowa, New Jersey.
- Rumsey, T. S., J. Bitman and H. Tao. 1983. Changes in plasma concentrations of thyroxine, triiodothyronine, cholesterol and total lipid in beef steers fed ronnel. *J. Anim. Sci.* 56:125-131.
- Rumsey, T. S., J. Bitman, H. Tao and A. S. Kozak. 1985. Changes in plasma concentrations of thyroxine and triiodothyronine in beef steers fed different levels of propylthiouracil. *J. Anim. Sci.* 60:1454-1462.
- Steel, R. G. D. and J. H. Torrie. 1960. *Principles and Procedures of Statistics*. 481 pages. McGraw-Hill Book Co., New York.
- Ward, J. L., T. S. Rumsey, A. S. Kozak and K. P. Bovard. 1984. The effect of 2,4,5-trichlorophenol on thyroxine (T<sub>4</sub>) and triiodothyronine (T<sub>3</sub>) plasma concentrations in beef steers. *Va. J. Sci.* 35:73. (Abstr.).



**Virginia Academy of Science Executive Committee Meeting**  
**May 25, 1988**  
**University of Virginia (Ruffner Hall)**

The meeting was called to order by President Banks at 12:20. Present were R. D. Decker, S. Ware, J. Martin and P. Homsher.

President Banks asked what was to be dealt with at the Academy Conference. He suggested that thanking the LAC would be appropriate at the conference as would any suggested by-law changes, mentioning that the by-laws and constitution are printed in the Journal, that the first teleconference of a VAS meeting will be done by the Engineering Section, and the place, dates and LAC Chair for next year are Virginia Commonwealth University, May 23-26 and Dr. Thomas Haas of the Engineering Section.

President Banks reviewed the content of his President's report to the Council. He recommended a Membership Committee change that the author or one of the coauthors must be a member of the Academy, and the presenter must be registered for the meeting. It was also suggested that students from the sponsoring institution can attend the meeting without charge. S. Ware suggested that all presenters should also be members of the Academy but with two exceptions: 1) invited speakers and; 2) students, both graduate and undergraduate.

President Banks reviewed the audit recently received and, after discussion, it was deemed to be satisfactory.

R. D. Decker stated he needs two names, one male and one female, for the AAAS Award for VJAS participants. The mechanism for determining these names is not well spelled out, but these names must be sent to S. Ware by May 28.

R. D. Decker also brought up a cooperative venture between North Carolina, South Carolina and Virginia teachers to develop a method of evaluating the teaching of biology from kindergarten through first year college. Each state needs a sponsoring organization for a grant to fund this and North Carolina has gotten their state Academy of Science to do this. R. D. Decker requested that the VAS be a co-sponsor on this grant request for the tristate Biology Curriculum Committee, probably to NSF. President Banks will bring this before the Council.

P. Homsher pointed out that the minutes of the March 12 Council meeting indicated that there would be a discussion at today's meeting about the purpose of the exhibitors and whether they should be continued, but that it did not appear on the agenda. President Banks acknowledged its omission and added it to the agenda.

The meeting was adjourned at 1:04 P.M.

Submitted

Paul J. Homsher

Secretary, VAS

**Virginia Academy of Science Council Meeting  
May 25, 1988**

**University of Virginia (Ruffner Hall)**

President Banks convened the meeting at 1:13 P.M. Present were J. Murray, E. Thompson, A. Branigan, D. Ulrich, A. Conway, R. E. Johnson, R. D. Decker, J. O'Brien, W. West, Jr., F. Leftwich, J. Martin, S. Ware, M. Bass, C. O'Neal, S. Colucci and P. Homsher. The minutes of the Executive Committee and Council meetings of March 13 were approved as distributed.

President Banks reported that the 1989 annual meeting will be at Virginia Commonwealth University, May 23-26. Dr. Thomas Haas of VCU and the Engineering Section will chair the LAC. Dr. Haas is responsible for the teleconferencing of the Engineering Section meetings for the first time at the present meeting.

President Banks reported that there was no formal invitation to host the Academy from any institution in 1990 but the University of Richmond may invite us. The 1991 meeting will be at VPI and SU.

President Banks requested a motion for the VAS to co-sponsor with the academies of North Carolina and South Carolina, a grant to hold a tristate conference on evaluation of biology teachers, K-first year of college. The motion was made by P. Homsher and seconded by J. O'Brien. The motion passed unanimously.

President Banks introduced two issues forwarded by the Membership Committee. They dealt with membership in the Academy and the presentation of papers at the annual meeting. First was a recommendation that each paper must have one author who is a member of VAS, and second, the presenter of the paper must be registered for the meetings. President Banks then introduced S. Ware to discuss these and recommend other changes. S. Ware suggested that at least one author of each paper must be a member of VAS with the exception of invited speakers. This was put into a motion by P. Homsher and seconded by D. Ulrich. The motion passed unanimously. E. Thompson moved that all presenters, except invited speakers, at the annual meeting must register for the meeting. A. Conway seconded the motion. The motion was approved unanimously. The President-elect, as chair of the annual meeting, will be informed about these two motions as will the Section Chairs and Secretaries.

President Banks pointed out the work that J. Martin has done as Editor of the Journal and how well he has done it. F. Leftwich moved an expression of thanks to J. Martin from the Council for his fine job in producing the Journal. W. West seconded the motion. The motion was approved unanimously.

P. Homsher moved that first-time student registrants be given membership for one year. J. O'Brien seconded the motion.

The motion was approved unanimously. It was recommended that a permanent address for students be requested so that VAS literature and the Journal could be sent to them at a location that increased their chance of receiving these and reduced the chance that they would be returned.



S. Ware brought up several problems that he had with the 1988 meetings. He stated that when he ran out of abstract forms, he found no more were kept in reserve. He also stated that the University of Virginia would not assign space to the sections until the insurance plan was approved. This and the lateness of Section Secretaries in sending their space needs to the LAC caused the program to be sent out later than usual. The question raised was "Should the program be printed without the late section room assignments?" S. Colucci was not present so the LAC report was deferred until he arrived or until the Council meeting on May 27.

President Banks introduced M. Bass who reported for the Long-Range Planning Committee (See Appendix 1). Discussion centered around the fund raising recommendation. It was stated that, if state funding is attracted, there will be limitations associated with its use. Large donations should be pursued but solicitations by VAS should not interfere with funding attracted by VJAS. Further discussion centered around the frustration of having science advisors which, although identified to the state government, are seldom used.

S. Colucci arrived and gave the LAC report. He stated that all VJAS students had a bed, all meeting rooms had A-V equipment, registration and exhibitors had to be moved around but all are now in place. VJAS awards will be sent to those not present at the awards ceremony, and the VJAS picnic will be in Newcome Hall.

President Banks introduced E. Thompson to give two reports: 1) his report as VAS representative to the AAAS Council (Appendix 2); and 2) his report as chair of the *ad hoc* committee on VJAS Future Planning (Appendix 3). There was little discussion about his first report and the report was submitted without change. His second report included three options for a paid vs volunteer Director. The third option, a paid professional director, was the recommended option, and a newly reconstituted Fund Raising Committee would be charged with raising \$60,000 seed money for it. F. Leftwich moved the committee recommendation and A. Conway seconded the motion. The discussion centered around the proposed budget of \$42,000-\$50,000 for all costs of the proposal. The successful candidate would take over the VJAS directorship at the onset and, assuming he/she is successful in generating adequate funds, would assume the Executive Secretary/Treasurer position when that became available. The committee felt that a budget of \$60,000 for one year of operation in 1990 (when the plan is proposed to be implemented) would be adequate. The President asked for a vote on the motion and the motion was passed unanimously.

President Banks introduced D. Ulrich for the Trust Committee report. D. Ulrich distributed the report (Appendix 4). There was discussion about the Bethel Fund and the fact that they were granting an award which is beyond the income of the fund. R. D. Decker agreed to contact them and discuss this problem.

D. Ulrich pointed out that two members of the Trust Committee were in their third year of service and that Council needed to reappoint them or



appoint new members. The appointment of Trust Committee members for these two positins will be made at the Friday, May 27 Council meeting.

P. Homsher moved and E. Thompson seconded a motion to commend D. Ulrich for the job he has done in overseeing the Trust Fund as chair of the Trust Committee. The motion passed unanimously.

President Banks thanked E. Thompson for chairing the *ad hoc* committee on the Future of VJAS

J. O'Brien requested, for the News and Information Committee, information on state scientific organizations to pass on to VAS sections in the form of a directory. Send this information to J. O'Brien.

E. Thompson indicted there was a room change for the Sections Editors meeting and asked all to distribute this change at their section meeting.

President Banks thanked all at the University of Virginia for doing such a fine job in putting the meeting together. He stated he knew of no by-law changes to be brought before the Academy Conference and he stated all VAS awards would be made at the banquet but the Elections Committee will make their report at the Academy Conference.

President Banks thanked all for their cooperation over the past year.

The meeting was adjourned at 3:57 P.M.

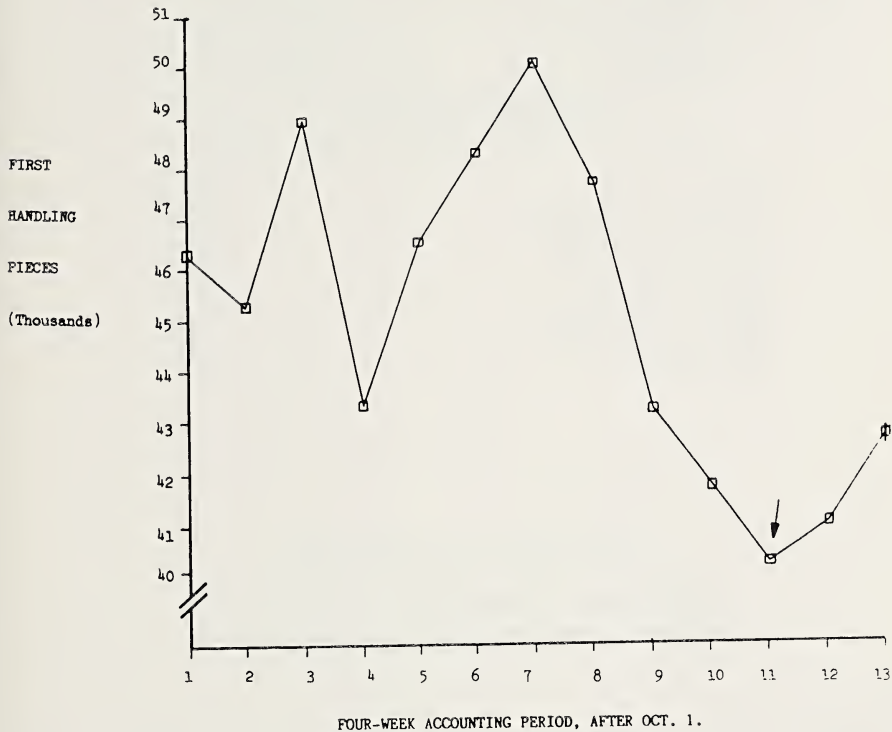
Submitted

Paul J. Homsher

Secretary, VAS

This figure was omitted from VJS 39(1):23-27, Staffing Analysis and Volume for Small Post Offices, *L. A. Rowe*, U. S. Postal Service and *K. P. Bovard*, Department of Animal Science, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

FIGURE 1. Expected mail volume for Roanoke, Virginia, FY 87



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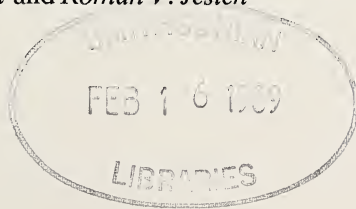
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# CONFERENCE ON STRATEGIC DEFENSE, ARMS REDUCTION AND WORLD SECURITY

## INTRODUCTION

On March 23, 1983, President Reagan stated, "I call upon the scientific community who gave us nuclear weapons to turn their great talents to the cause of mankind and world peace, to give us the means of rendering these nuclear weapons impotent and obsolete." With these words the President committed the nation to a ballistic missile defense program, and in the process, ignited a heated debate among scientists, academicians, politicians, and the general public as to its feasibility, and alternative means of reducing the risk of nuclear war.

The Strategic Defense Initiative (SDI) or Star Wars, as it has come to known, has emerged as an important issue affecting U.S.-Soviet relations (especially progress toward further nuclear weapons reduction), the U.S. economy, and the 1988 Presidential election. It continues to have an important influence on other aspects of nuclear and conventional arms control.

The objective of the Conference on Strategic Defense, Arms Reduction and World Security was to enhance public understanding of this important issue. It was organized by the Study Group on Arms Control and World Security, which consists of approximately twenty active and retired members of the University of Virginia faculty, representing a variety of academic disciplines and philosophical viewpoints. The objective of the Study Group is the establishment of a permanent program at the University of Virginia for instruction, research and public information in arms control, world security and related areas.

The conference was divided into four sessions, each featuring two speakers offering differing views, and a moderator. The presentations were followed by a question-and-answer period and discussion. These proceedings are based on transcripts which have been edited by the conference co-chairman W. Reed Johnson, Professor, Department of Nuclear Engineering and Engineering Physics, and John R. Redick, Associate Professor, Division of Continuing Education, with the cooperation of Alfred P. Fernbach, Professor Emeritus, Department of Government and Foreign Affairs, and Mr. John Hannon, Department of Nuclear Engineering and Engineering Physics, all of the University of Virginia.

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## CONFERENCE PROGRAM

## SESSION ONE -- SCIENTIFIC AND TECHNICAL PERSPECTIVE ON THE STRATEGIC DEFENSE INITIATIVE

Moderator, Dr. Hugh P. Kelly, Dean, Faculty of Arts and Sciences,  
University of Virginia

Speakers, General Garry Schnelzer, Deputy for Technology,  
Strategic Defense Initiative Organization

Dr. Wolfgang Panofsky, Director Emeritus, Stanford Linear Accelerator  
Center

## SESSION TWO -- ECONOMIC AND STRATEGIC IMPLICATIONS OF THE STRATEGIC DEFENSE INITIATIVE

Moderator, Dr. Kenneth W. Thompson, Director, White Burkett Miller  
Center for Public Affairs, University of Virginia

Speakers, Mr. John E. Pike, Associate Director for Space Policy,  
Federation of American Scientists

Dr. Keith Payne, Director of Research, Executive Vice President,  
National Institute for Public Policy

## SESSION THREE -- THE SOVIET UNION AND STRATEGIC DEFENSE

Moderator, Mr. Paul B. Stephan III, Professor, School of Law, University of  
Virginia

Speakers, Dr. John Edwin Mroz, President, Institute for East-West Security  
Studies

Dr. Stephen Neil MacFarlane, Associate Professor, Department of Govern-  
ment and Foreign Affairs, University of Virginia

## SESSION FOUR -- SDI, ARMS REDUCTION, AND FUTURE GLOBAL SECURITY

Moderator, Mr. Philip M. Nowlen, Dean, Division of Continuing Education,  
University of Virginia

Speakers, Colonel Stephen O. Fought (U.S. Air Force, Ret.),  
Professor, Naval War College

Dr. Betty Lall, Senior Fellow and Director, Arms Control Verification Studies,  
Council on Economic Priorities

## Session One - Scientific and Technical Perspective on the Strategic Defense Initiative

Moderator: Dr. Hugh P. Kelly

Speakers: General Garry Schnelzer

Dr. Wolfgang Panofsky

Gen SCHNELZER:

Indeed it's a pleasure to be with you, and with Professor Panofsky.

I'd like to say that we in the Strategic Defense Initiative Organization really like the title of your program today: Strategic Defense, Arms Reduction and World Security. I don't think there's a person in uniform that doesn't want world security and peace. The kind of peace that would be agreeable to Thomas Jefferson; that is, with freedom. You really can't talk about the Strategic Defense Initiative unless you take a step back and talk about its beginning. Formally, it's only 5 years old, having started on March 23, 1983, when the President, in a speech to the nation, asked the scientific and engineering community to take a look at our technology and see if indeed a strategic defense might be possible. If the possibility existed, then a more stable relationship might exist between the United States and the Soviet Union.

Why in 1983 did President Reagan say that strategic defense was a proper course to look at? You really have to go back to 1972 and the signing of the strategic arms limitation agreement, SALT I, and the anti-ballistic missile (ABM) treaty. Of particular importance was the logic behind the ABM treaty, which I am sure will be talked about tonight and in my opinion should be. The U.S. mindset in 1972 was that strategic defense was not technically doable. If you combined this with the concept of mutual assured destruction (MAD) -- some people would say mutual assured suicide (*i.e.*, you hold each country hostage to nuclear weapons) -- then there really did not seem to be any reason for the proliferation of ballistic missiles. The ABM treaty was intended to put a lid on ICBMs. However, the Soviets kept building ballistic missiles while we stopped. In the mid 1970s, the Soviets deployed a MIRVed missile, the SS-18 which for the first time gave them the potential of a preemptive first strike. They have followed the SS-18 with several newer ICBMs and submarine-launched ballistic missiles (SLBMs). Last year, the U.S. deployed its first new ICBM in over 15 years -- the Peacekeeper.

Why is the land-based ICBM so important? It's the one nuclear strategic system that can be launched quickly, that has a very short time of flight, and that has the accuracy to achieve significant damage against hardened targets. Like the SS-18, it can have the characteristics of a preemptive weapon *i.e.*, take out your opponent before he can strike back. If one side possesses a preemptive capability,



then "mutual assured destruction" is no longer mutual. Under this situation, the balance of offensive weapons between the USSR and U.S. no longer is maintained, and you no longer have stable nuclear deterrence. It is the evolution of the Soviet ICBM threat and its impact on creating less-than-stable deterrence that requires us to examine strategic defense. It is also our strong desire to transition from an offense-dominant deterrent to a defense-dominant deterrent. It may offer the stability in a crisis that we don't have today. For example, if you take away a Soviet planner's certainty that he could stage an effective pre-emptive attack, you have reduced the chances of the nuclear "trigger" being pulled.

The real issues for strategic defense are: how good can you make it and can you afford it? First let me talk about its effectiveness. The key to strategic defense in the 1980s and 90s, versus in the 60s and 70s, is that today, with the technology we are developing, we can talk about a multilayered concept; that is, space-based as well as ground-based defense, with distinct defensive layers. If we consider a single defensive layer destroying eighty percent of the targets (*i.e.*, twenty percent get through), then a Soviet planner has to essentially dedicate one SS-18 with its 10 warheads against one target to get a high probability of kill. If there are two defensive layers, independent ones, each with the same kind of performance (20 percent leakage), the force the Soviet planner has to use goes up by a factor of roughly ten (*i.e.*, ten SS-18s). A third layer provides a further large increase in effectiveness. You see, from the Soviet perspective, the value of his most important strategic weapons has been diluted tremendously. Even more significantly, he doesn't know which of his warheads will be defeated. The multilayered defense has taken away any confidence he might have in terms of engaging in a preemptive strike. In the multilayered concept there are different challenges for the defense in each layer; however, this approach also provides the defense significant leverage against the offense.

Now, can we build, with good reliability, that multilayered defense? To do that, we've got to go to space. A space-based defensive system provides a capability to destroy the booster as it is lofting its multiple warheads toward their targets. If you can kill an SS-18 booster, for example, there's a tremendous benefit: you get ten warheads for every booster kill. After the booster burns out, it goes into a semi-coast phase -- it's called the busing phase; it's literally a bus that off-loads, as it flies along, each warhead at a point that gives each one its proper ballistic trajectory. If the booster is not destroyed, then there is the opportunity to go after the bus. There is still tremendous leverage in going after buses. Destroying a bus that might have already off-loaded five warheads, still means the five remaining warheads will have been killed for the price of one interceptor. So it's in this high payoff region of boost and post-boost that we're concentrating our long term technology research programs. Once the reentry vehicle (RV) has been off-loaded from the bus, the midcourse phase of the battle is entered. Now the defense must go after single RVs, and be able to distinguish RVs from decoys that might be deployed to fool the defense's sensors. However, in the midcourse phase there is more time to work -- roughly twenty minutes versus the three to five minutes in both the boost and busing phases. The problem here is discrimination, and that is another major area of our research program.

In the last minute and a half of flight, the RV must fly through the atmosphere. That's a short period of time, but there are some distinct advantages for the defense in this terminal phase. As the RVs and decoys come back into the atmosphere, the lighter decoys are slowed down by the atmosphere and are therefore easier to distinguish, making the targeting of the RVs possible.

Now where do we sit with the technology to provide for the multilayered capability? Can we build it to the performance we need, soon enough, and can we afford it? Affordability is a key issue. Recent estimates have concluded that the first phase of an SDS can be built within acceptable cost bounds, but we are dedicated to reducing the cost to an absolute minimum. Some of the cost reduction efforts are included in my discussion of the technology efforts.

Let's examine the eyes of the system - the sensors. First you've got to detect the booster. Its plume can contain over a megawatt of energy; that's like 10,000 hundred-watt light bulbs. Because it's so bright, a satellite using infrared sensors, which detect hot objects, can easily detect and track the booster. From its high perch, one satellite can look at a whole hemisphere, so you don't require a lot of satellites to cover the earth. This type of infrared technology has been around for a long time, and what we are essentially doing is improving it. In midcourse, you go from tracking a hot booster or bus to cold RVs and decoys, both of which may only give off a couple of watts of energy, literally a two or three watt light bulb. Using long-wave infrared detectors, that can detect relatively cold objects against the even colder background of space, RV's and decoys can be tracked. These detectors would be used in both space-based surveillance satellites and ground-based probes. In the long-wave infrared technology, there have been tremendous strides in the last four years. Detectors are ten times as good as they were three years ago; and ten times more resistant to radiation. We are also making great advances with signal processing, which is absolutely key and probably the toughest part of the technical challenge. Given even the tremendous strides we've made in the technologies, we still have to integrate them, *i.e.*, assemble the hardware, write the software, and make it operate. We're integrating, and checking out, midcourse sensor concepts using an airplane testbed.

The integration experiment is called the Airborne Optical Adjunct (AOA). Using a Boeing 767 and a half-meter aperture sensor, we will, for the first time, demonstrate the technology useful for meeting the midcourse sensor requirement. The AOA is impressive. The focal plane is sampled 385 million times a second. I've heard a Hughes engineer discuss this as reading the Encyclopedia Britannica, all nineteen volumes, seventeen times each second. There is also onboard a 25 million instructions per second data processor to evaluate the data. The AOA will be flying this coming year.

The sensor for the terminal and midcourse phases is a radar. Even though radars have been around for a long time, don't let this one deceive you. It's a higher-frequency radar; therefore, it works a lot better in a nuclear environment than the ones we've used in the past. It also provides very high resolution at very long distances, and it will offer us a possibility of discriminating RVs from decoys in midcourse. We have already performed a space experiment to address the sensor discrimination challenge, and to determine if we really know what we are looking at (*i.e.*, how carefully can the Soviets disguise the RV with a decoy?). We flew the



experiment, called the Delta 181, last February. We are proud of it for a couple of reasons. One is that it was launched in less than two years. It's something that we felt we'd lost the ability in this country to do; to build and fly a spacecraft quickly. Once in space, the Delta 181 spacecraft, using infrared, visible, ultraviolet, laser radars, and microwave radars, characterized an array of sophisticated targets. This allowed us to see how well we could distinguish the differences between RVs and decoys in an actual space environment.

Next let's talk about weapons. Rocket-propelled kinetic energy weapons have been around for a long time. The space-based interceptor (SBI) element is composed of interceptor rockets used to destroy boosters, buses and RVs in midcourse. The SBI is an element of our program that we've probably made the greatest strides, especially in the last three years, and one which has witnessed dramatic cost reductions. The SBI is complemented by a ground-launched missile called the exoatmospheric re-entry vehicle interceptor system (ERIS). ERIS intercepts its targets outside the atmosphere, in midcourse. Within the atmosphere, there is the High Endoatmospheric Defense Interceptor (HEDI).

These kinetic energy weapons employ the principle of hit-to-kill *i.e.*, you hit a bullet with a bullet. This can be done because we've developed extremely lightweight and smart guidance electronics. We're talking non-nuclear. In 1984 the Army, in their Homing Overlay Experiment, flew a missile out of Kwajalein in the Pacific towards an incoming American RV and hit it dead center at a closure rate of tens of kilometers a second. Imagine that; tens of kilometers a second and hit it right on the nose. They did it using an infrared sensor which guided the missile right into the path of the incoming warhead. That's the same way a space-based interceptor system would work against a booster or RV.

Let me go through very quickly some of the gains in space-based interceptor technology. The thrust and weight ratio of a rocket motor determines how fast you go. In 1980, a typical ratio was twenty to one -- twenty pounds of thrust to every pound of weight. By 1986, we were at 200:1, and in 1987, 400:1. Today we have achieved over 1200:1. Inertial measurement units enable a satellite or missile to navigate. In the 1980s, typically, they weighed about 41 pounds and cost about seventy thousand dollars. We were going to fly one this year that weighs two pounds and cost fifty thousand dollars. In the laboratory, we have new technology that has reduced the weight to half a pound and the cost to eight thousand dollars.

Directed energy weapons get all the press and about twenty-five percent of the budget. Ground-based free electron lasers (FELs), using space-based mirrors to guide the beam against the booster, and space-based chemical lasers have enjoyed significant progress. Neutral particle beams also offer promise. A particle beam penetrates the booster or RV and destroys the electronics. If of sufficient power, a particle beam weapon, like a laser, can also "burn through" a target. A very promising experimental chemical laser designed for space basing will be tested in Capistrano, California, this year. This country has the technology to fly a chemical laser experiment in space by 1995. It would be fairly large, requiring two separately launched payloads to be mated in space.

Free electron lasers are actually working at the Boeing facility in Seattle. We're building a facility at White Sands, New Mexico, to explore further this high-powered laser technology.



Of course, for lasers or particle beams to work, you've got to point them very well and hold them on target, probably a tougher problem than generating the beam. The Starlab experiment, which will fly in 1990 on the shuttle, will demonstrate the tracking and pointing accuracy that will be required by directed energy weapons.

Many people say battle management software is the nemesis of strategic defense. That's been said for many many years. In the 1960s, the National Academy of Science said you could never build the Safeguard antiballistic missile system since it required a twenty-five million instructions per second computer. Nevertheless, it was built and worked. Today we are examining the total battle management challenge; for example, how best to fuse data and extrapolate what may appear later in the battle. For a Strategic Defense System, you will no longer be restricted to looking at a small part of the battle; you will be able to look at the total battle as it evolves.

To support the battle management development process, we've got a National Test Facility under construction at Falcon Air Force Station in Colorado Springs. It will be the center for developing and testing the battle management software.

Electronics are surely a key to performance, in weapons, sensors and battle management. We are achieving very high speed integrated circuits using sub-micron technology that is radiation-hard. A small chip that's a couple of inches on a side has the power of a mainframe computer. This technology continues to evolve at a rapid pace.

I'd like to point out that we have a very active civil applications program in SDI. As one example, over fifty million dollars have been spent on the application of the free-electron laser (FEL) for medical research. Orthopedic surgery using FEL's is being explored in a number of places *e.g.*, Massachusetts General Hospital in Boston. Using the laser, the bone cuts are so fine that the healing process can be significantly increased. The FEL is also being used in cancer and heart disease research.

I've used far more than my time, and I thank you for listening. However, there is one more thought I'd like to leave with you. I recall that in 1895, Lord Kelvin said, "heavier than air flying machines are impossible." I'm sure Britain wished it had a few more flying machines in 1914.

Dr PANOFSKY:

Dr. Johnson, Dean Kelly, ladies and gentlemen. General Schnelzer and myself are proceeding from essentially the same scientific and technical facts, and there is no significant disagreement about those, and I will therefore not repeat them. I do have serious disagreement with General. Schnelzer's first graph, illustrating the threat, because he only chose to project the land-based missiles where indeed the Soviets are greatly leading, but he did not include either the bomber-component, or the sea-launched part of the threat on both sides, and he did not show the total build-up in total number of warheads of all these things combined, where the United States, at the present moment, is still slightly ahead of the Soviet Union. At any rate, the total numbers are so enormous that even a very small fraction of both penetrating can make enormous amounts of damage. So therefore there are some divergences in view of the perspective flowing from the facts.

I'd like to point out that classification, that is, secrecy, on SDI technical material, has only minor impact on the perspective. It is very pleasant and in the spirit of Jefferson necessary that, on something as important as the future of SDI, intelligent public discussion should be possible. It is noteworthy that the report of the study of the American Physical Society on directed energy weapons, in which I participated, was carried out with access to classified information, and when it was then submitted to the Strategic Defense Initiative Organization for clearance, only very minor loosening of some specific numbers was necessary in order to produce an unclassified volume. Similarly, in the recent study by the Office of Technology Assessment of the Congress on SDI technology, relatively little dilution of the content was necessary in order to have it be open for publication; however, unfortunately, the chapters on countermeasures against ballistic missile defense, on the survivability of the SDI system, has remained classified. And this is an important matter, because the essence of the question of SDI is not so much whether it can work, whether you can shoot something down, but whether in the overall balance of offense, defense, countermeasure, counter countermeasure, counter counter countermeasure, so forth, who wins and who loses?

Now one of the reasons for the variety of views on the technical perspective in SDI is that there is a lack of clarity on the SDI mission, namely what it is for. The original statement by President Reagan, on March 23, 1983, urged the scientific community to make ballistic missiles "impotent and obsolete." But in fact this statement is no longer really the guidance under which the Defense Department is operating. The focus has shifted to several distinct missions. One, to complicate the task of an attacker and thereby make first-strike attack less likely. That is essentially the motivation which General Schnelzer gave, namely, if there is ballistic missile defense, in that case if the other side planned a first strike attack, he would have to worry not only about the retaliation of our surviving weapons, but also would have to worry about the marginal penetration of his own. Secondly, to defend the retaliatory forces of the United States against pre-emptive attack. That means, if we can protect our retaliatory missiles, by defense, then presumably more of them would be left over to retaliate. And then, finally, to defend the nation against accidental or unauthorized ballistic missile launches, which are presumed then to be minor. That particular third mission has come into focus by a speech made by Senator Nunn of the Senate Armed Services Committee.

But it is notable that none of these missions contradict the basic notion of deterrence, or MAD, as General Schnelzer mentioned -- that is the concept that the purpose of the United States nuclear arsenal is to persuade the adversary that he cannot attain any valid objective by initiating war against the United States. Thus President Reagan's vision, to substitute stability achieved by defense on both sides for the current strategic stability resulting from reciprocal threat of offensive action, is not being implemented by the current programs, therefore relieving the balance of terror is not the current SDI mission. Now this policy shift, from President Reagan's original speech, is generally covered by the statement relegating the expectation of stability through mutual defense to a long-range objective, not within the purview of the current SDI program. No one proclaims the impenetrable shield as a current SDI objective.



Now differences among all informed participants in the current policy discourse tend to be based on their divergence of expectations, how past achievements in ballistic defense research can be extended and extrapolated into the future. Here, of course, reasonable men can differ, but I believe that no one can reasonably maintain that current technology permits a deployment decision of a defensive system designed to perform any of the missions enumerated above within a time short of at least a decade.

Now the three missions which are enumerated above require considerable differentiation in the technology required to achieve a defense. Complicating the task of the attacker simply means that deterrence is to be enhanced by mixing defenses with the retaliatory offensive systems. This presumably would blunt the enemy's attack and he would have lessened confidence in attaining his objective. But deterrence can also be enhanced by further augmentation of offense, and the question must be asked whether deterrence needs strengthening at all, whether we have not, in fact, reached sufficiency. Analyses show that the United States strategic forces are sufficient to retaliate with over one thousand nuclear warheads even if attacked out of the blue without any strategic warning or tactical warning at all. Even if START reduced the forces by one half, still one would expect that well over a thousand nuclear warheads would be available for retaliation.

Therefore the advisability of deploying defenses is at some level both a policy and an economic question. Is the enhancement of deterrence cheaper by adding defenses to the offensive arsenal, by any of these technological means, or can the offensive arsenal be upgraded at lesser cost? Added to this question of economy are the criteria generally attributed to Mr. Nitze, who is the President's Special Advisor on Arms Control. The Nitze criteria have been adopted as national policy by executive order of the President. That means the official criterion is not only, as General Schnelzer said, affordability -- what ever that means -- but it also is based on what is called cost-effectiveness on the margin. Let me explain that particular term: supposing we spend X bucks in putting up a defense, and the other side then spends Y rubles in increased offensive measures, and to an extent that we are left just as vulnerable as we were before. Let's assume for the moment that a buck and ruble is the same, then if Y is much less than X, then presumably all we have done by putting up the defense is to escalate the arms competition to a higher level and we have not increased the survivability of our nation and our forces.

Similarly, the second Nitze criterion is that we must have survivably based defenses; that means that the other side cannot simply attack the base of defense and thereby negate it. Now I believe that none of the technologies which I have seen here and which I'm aware of are such that a persuasive case has been made or can be made by any of the advocates and performers of SDI, that any of the systems meet these economic criteria. In other words, if you do have a defense-offense competition that financially you would be ahead of the game.

Now the mission of enhancing deterrence by defenses demands both defending population and the means of production as well as defending the retaliatory strategic forces in some appropriate mixture between those two objectives. Now if one wished to protect the strategic retaliatory forces only, then technology requirements are very much simpler. The reason is that our retaliatory forces are located at specific points and one only has to defend what one calls a "threat tube," name-



ly that part of space which threatens that particular object. So therefore, the technologies required, whether one wishes just to protect retaliatory forces or the entire nation, are quite different.

Now the third mission objective, that is, the use of ballistic missile defenses as protection against accidental or unauthorized launches, has come into recent focus through the speech by Senator Nunn, on which I commented before. He pointed out that, if there were an accidental launch, it would presumably be small and therefore even if SDI defenses were to have only very limited capability, it might be sufficient to blunt the effect of such an accidental attack. Now the assumption that accidental attack would be small is, of course, somewhat dubious, because of the fact that it depends entirely on what went wrong, and considering the fact that the Soviet forces carry multiple warheads, it is not clear how small or how large an accidental or unauthorized attack would be.

Now the issue here is whether the nation should be sufficiently concerned about the possibility of accidental or unauthorized launch to take remedial action. If we are indeed concerned about the frightening possibility, and I believe we should be, then the relevant question is whether ballistic missile defense is the proper means to deal with it. Alternate approaches would be for us and the Soviets to strengthen our safeguards against accidental, unauthorized launch by, for instance, extending the use of permissive action links -- these are devices which require codes to be entered from higher echelons to the entire strategic force. Currently the naval component of our strategic forces does not have permissive action links. Currently submarines can, in principle, release their ballistic missiles without any enabling code received from higher headquarters. There are, however, procedural safeguards such as multiple key systems, to make such unauthorized release highly unlikely, but one can obviously hope, like in all safety matters, to do better.

Other means to strengthen safety against accidental and unauthorized release come to mind, and this could well be a fruitful topic of dialogue with the Soviets in this era of *glasnost*. One measure worth considering to prevent accidental release would be to introduce the technology into the operational force which is now used for range safety instrumentation for missile test launches. Under such an arrangement, command destruct packages would be attached to each launch vehicle, as is currently done during missile tests, in case a missile goes in the wrong place. In such tests, the range safety officer can order the destruction of the missile launch if the vehicle flies on a course perceived to be dangerous. Of course if such a means to prevent accidental launch were adopted, it would have to be very carefully encoded in order to make it impossible for the other side to invoke the range safety instrumentation. But I believe, in accordance with General Schnelzer's advances in technology and coding mechanisms, that this is an easy task. In other words, if one is concerned about the problem, about intercepting unauthorized launches, then using ballistic missile defenses is only one, and in my view, the least promising of the means to deal with the particular problem.

If one concerned about enhancing deterrence by complicating the tasks of the attacker, then indeed ballistic missile defense would do that, but one has to compare the merit of ballistic missile defense with other means to enhance deterrence, such as further offensive measures, or arms control. Therefore, if, on the other hand, one wishes to change the current balance of terror to a balance of defenses,

which is the content of President Reagan's speech on March 23rd, 1983, then we are talking about the impenetrable defense, or near-impenetrable defense, and this is not a current objective, or even a goal which is very much identified any more, except as a possibly long-range further step in the current SDI program.

So that is basically the context which I would like to mention. We have agreement here on technology, but one has to be clear as to what mission one wishes to address with that technology, and one has to look not only as to whether technology works -- for instance the question, "Does it work or does it not work?" -- which is the most common question the layman asks, has no meaning at all. It depends what "it" is -- namely, what the mission is; and it also depends not only whether it works, but whether it meets the economic criteria which show that this method has merit relative to other means of satisfying the same mission. And that is a thing which one should not forget in these discussions.

Now let me make some remarks on the alternate SDI technologies, and I have very little to add to General Schnelzer's remarks. A reasonably complete discussion is obviously not possible in the time available. General Schnelzer already mentioned that SDI technologies attempt to interact with ballistic missiles in three phases: the initial boost phase, the separation phase, in which the multiple warheads, if any, are separated from the bus; in midcourse flight; and during the terminal re-entry phase when the warhead re-enters the atmosphere. Most systems considered in the SDI program focus, as General Schnelzer indicated, on a multi-layer defense.

Now boost-phase intercept has a great advantage in that the missile booster is relatively soft and that if the booster were successfully killed then you are killing the entire payload of that booster, and you don't have to attack each warhead one at a time, if there are multiple warheads carried. The disadvantage of boost-phase attack is that the length of the boost phase is under the control of the attacker, and the development and use of what's known as fast-burn boosters and the use of what's called depressed trajectories can shorten or deny the defense the opportunity for boost-phase attack. Another thing is that during the boost phase the plume of the exhaust offers a rich source of radiation, and as General Schnelzer indicated, of the general order of a hundred kilowatts or even more total irradiated power, and that is easy for target acquisition and the initial guidance of interceptor; however, the plume and the actual vehicle are not in the same place and it doesn't do any good to shoot at the plume, the exhaust plume, so therefore, all boost-phase intercepts have to be supplemented not only by the sensors which can observe this highly bright object, but also by some form of terminal guidance which involves a much more complicated active means of radar, possibly radar operating in the visible region.

Now interceptor technologies are divided into what's called kinetic energy devices and directed energy devices. Now, let me talk firstly about kinetic energy devices. The leading candidate for that is the so-called SBI, space-based interceptor, that's a fancy name for interceptor rockets which are based from satellites in space. Directed energy weapons attack the target either with particle beams or beams of electromagnetic radiation, both of which propagate essentially at the speed of light. Now there's general consensus that the development of SBIs is more advanced than that of directed energy weapons. However, the development of neither technology is sufficiently advanced to permit a conclusive evaluation of their



promise in an ABM role if one applies meaningful economic criteria; that means if one does not just apply the criterion does it work, doesn't it work, or is it affordable, not affordable, but if we ask the question relative to other means to defend the nation, relative to other means of complicating the task of the attacker, is this was way to go.

Let me first turn to SBIs, to the space-based interceptors. To be of value in attacking the boost phase, SBIs would have to be in place in orbiting satellites. Of such satellites, only a small fraction will be within range of the incoming booster, and therefore a very much larger number of satellites has to be deployed than can participate in the attack. After all, one cannot expect the Soviets to wait with their attack until the satellites are so that they can be shot. The ratio of all the required satellites to those active in the attack is known in the trade as the absentee ratio, and the value of this absentee ratio depends critically upon the range and speed of the attack vehicles and on the altitude of deployment. Now a number between twenty to a hundred for the absentee ratio is a reasonable estimate. That means that only something between one to five per cent of the defenders can participate in the defensive action. That is, if a defense is to attack, say, five thousand boosters from the enemy, then you have to place a hundred thousand SBIs in orbit. For such a deployment to be cost-effective, the weight of the SBIs would have to be much smaller than that of the re-entry vehicles used in the attack, because otherwise the defense would have to loft very much more weight into orbit than the offense does. Similarly, you have a problem that it takes about three times more energy to put things into orbit than to put things into an ICBM trajectory. So putting these factors together, the only hope for SBIs to be cost-effective would be to drastically reduce the weight of the SBIs below their current value. Now General Schnelzer has indicated the very impressive achievements in reducing the weight of many of the components of SBIs; nevertheless, the current generation of SBIs weighs about two hundred or so kilograms per unit, and if you multiply that by the factors which are indicated, you find out that the total amount of material in space which you have to lift is totally prohibitive, on any economic criteria, even ignoring the fact that our total lift capability for the next decade is clearly inadequate for such a task.

Now miniaturization of electronics and guidance equipment does offer hope of a transition from current technology to what colloquially now have been called smart rocks or brilliant pebbles (laughter), but in order to go from the current two hundred or so kilograms to the brilliant pebbles, you are talking about an extension of technology which is wildly ahead of what is currently in view. Now even if further developments achieve a drastic reduction of mass, and SBIs would become a reality and it's certainly possible, over a very long period of time, the problem of countermeasures remains extremely serious. Because of the limited velocities of SBIs -- they're currently going at about six kilometers per second, and one may extend it to eight kilometers per second -- then if the other side simply reduces the time in which the boost phase is above the atmosphere and can be seen, in that case the effectiveness of SBIs gets drastically reduced and the system would fail most ungracefully. Let me give you, for instance, the example that the SS 18, the most threatening of the devices the Soviets have, which was in General Schnelzer's second slide -- there you have about five minutes in which you can look at the boost phase. For the SS 24, the number is only two minutes. And if you look at two



minutes and six kilometers per second, that means the range, even if you have no time to make a decision, would be seven hundred kilometers. If the range is short of seven hundred kilometers, in that case the total number of objects you have to deploy would have to be extremely dense all through the sky, and if the other side would decrease their burn-time even further, which it clearly could do over the next decade if it chose, in that case the whole system would fail catastrophically.

Now the situation in respect to directed energy weapons rather than kinetic energy weapons is different in some respects and similar in others. At this point in time the energy which can be delivered by existing lasers and particle beam devices is not sufficient to constitute a component of an effective system for attacking ballistic missiles.

Quite separately from providing a means of attack, particle beam devices may have a role in midcourse discrimination. The problem of midcourse discrimination which General Schnelzer referred to, how to tell decoys from the real thing, has not been solved. There are several means which are promising, and one of them is to use particle beam devices to examine how such particle beam devices interact with the real warheads relative to the decoys. And the ultrasound radar system that General Schnelzer referred to, but none of them are of proven effectiveness, and one cannot say that the problem of midcourse discrimination has been solved.

Now the interaction of particle beams, however, with warheads and decoys may play a useful role. However, having particle beams serve as a means to kill vehicles seems to be at this particular point looking extremely unpromising. The power source limitation is a very serious one if either particle beam devices or lasers have to be placed in orbit. One way to avoid this problem is to have the laser itself be powered by nuclear explosion. X-rays produced by a nuclear explosion can in principle, by a development called an X-ray laser be focused in an extremely narrow cone and such things are under development, largely at Livermore. The current situation is still such that many, many nuclear tests would be required to establish the feasibility of such a device. Aside from this issue, it is generally agreed that deploying such a device in orbit is not suitable, because the absentee ratio, discussed above, would make it necessary to deploy a very large number of nuclear weapons in orbit in the case of using nuclear explosions as a means to power an X-ray laser. Therefore one would have to have an instantaneous deployment of such a device from a forward base outside the continental United States.

However, the other fundamental matter: clearly to use nuclear weapons as a means to make nuclear weapons impotent and obsolete, to use the President's language, would certainly be a paradox which would have to be faced. So therefore at the present moment, the priority and promise of using the nuclear weapons-pumped X-ray laser as a means to intercept has been somewhat deflated.

A more promising solution is to place the directed energy device in the form of laser on the ground and then deploy a system of guiding mirrors in orbit and one of General Schnelzer's slides, viewgraphs, showed that particular device. This requires however that the wavelength of the ground-based laser be chosen to be able to penetrate the atmosphere without unacceptably degrading its optical quality. No laser of adequate power to satisfy this mission has as yet been developed. Nor has the problem of atmospheric penetration been fully solved. Quite apart from these issues, there is the question of the vulnerability of the mirrors in orbit to enemy

attack, which, again raises the question of the measure, countermeasure, counter countermeasure balance. You must recognize that if you want to use such a system, where you have a ground-based system, several mirrors in orbit, then the reflectivity, the quality of that mirror must be exceedingly high, because you want to burn up the other side's missiles, but you do not want to burn up the mirror. Therefore the reflectivity, the quality of that mirror must be exceedingly high, and must remain extremely high even in the enemy environment.

The most promising ground-based laser for this mission is a free-electron laser, FEL, to which General Schnelzer referred. This is a device where electron beams from high-energy accelerators are passed through what's known as a magnetic wiggler, which causes that electron beam to radiate very intense coherent radiation, with the wavelength of the radiation beam determined by the energy of the instrument's electron beam, the strength of the magnetic field in the wiggler, and the periodicity, number of wiggles per second in such a device. Successful devices exist in the laboratory and the one slide which General Schnelzer showed from the Boeing laboratory is one example. But in order to be of use for the SDI mission, the average power has to be increased by a factor of one thousand to ten thousand beyond anything that has been demonstrated in the laboratory. And the beams of electron accelerator required to feed such a device would have to be at least a hundred times larger than that of any existing machines in the world. None of these extrapolations appear to meet insuperable physical barriers but whenever one deals with extrapolation of this magnitude, predictions on cost, reliability of performance, and schedule remain highly uncertain.

The question of atmospheric penetration by a free-electron laser, or any other, laser remains an unanswered question at the present moment and obstacles may or may not be fundamental on that score. The installation in New Mexico which General Schnelzer referred to has as its primary objective to explore whether it is indeed possible at all to have a free-electron laser beam penetrate the atmosphere without an acceptable degradation in its optical quality.

These remarks are all very sketchy, but some general observation on the technical situation regarding directed energy weapons, DEW, are in order. One, all directed energy weapon devices to serve any of the SDI missions require extrapolations by several orders of magnitude, several factors of ten, above the current state of the art. Two, all DEW devices are much more powerful as anti-satellite weapons than they are as anti-ballistic missile weapons. In other words, as DEW development proceeds, it will first generate a danger to satellites in orbit, including those required for operation of the SDI system itself, as well as those military satellites which serve intelligence and battle management functions. One can justly ask whether it is a development which would enhance or diminish national security. Third, there is no indication whatever that any of the systems based on directed energy weapons will meet the economic Nitze criteria which I mentioned before, namely is it cheaper for the offense to defend the defense or the other way around.

I'd like to add, to these three remarks about directed energy weapons, the remark which I made before about kinetic energy weapons, and the space-based kinetic energy interceptors have a technology which is more readily at hand. However, the space-based interceptor systems fail disastrously if the other side



adopts the most simple of countermeasures, namely to reduce the total amount of burn time which is visible above the atmosphere.

Let me summarize some of these conclusions: I believe these remarks to be realistic. They do not constitute a basis for discouraging further research on ballistic defense missile technology, but they do urge caution in making predictions regarding the future impact of such technologies on the future military situation. They do argue strongly against basing national policy or the future of international treaty obligations on anticipated results from such research. I am in no way trying to belittle the achievements of the ballistic missile research program, either before the President made his speech in 1983 or after the inception of the current SDI program. Rather, this situation of urging caution is inherent in the basic physical circumstances produced by the advent of the nuclear age. Nuclear weapons have increased the explosive power which can be carried by a given vehicle by a factor of about one million. Thus the penetration and explosion of even one nuclear weapon is an event causing enormous damage, death and destruction. Now this has greatly tilted the traditional competition between offense and defense in favor of the offense. The standards which a defense has to meet in the nuclear age are very much larger than the standards a defense had to meet when we were dealing with conventional explosions. Since penetration of just such a single offensive weapon can wreak enormous damage, we therefore find that we have to have a defense which has to be extraordinarily effective in order to be economically the better way to assure the security of the nation.

These considerations are fundamental. I am not at all guilty of the charge which is implied in General Schnelzer's last slide, namely saying defense is impossible, the bumblebee cannot fly and so forth; that is not the issue here. The issue is not whether defense is possible; certainly defense is possible, certainly you can intercept one ballistic missile by one defensive interceptor. That is not even the question, that's not even the issue. It is also not the issue whether research should continue in exploring these methods. What is the issue is whether when you consider these things as a system, whether you have something which enhances security of the nation or whether in fact it makes the security of the nation less promising, considering the measure, countermeasure, counter countermeasure, and so forth, competition which will ensue. And that evaluation is not whether it can work or cannot work, but it depends very clearly on the economics of the overall situation, and there, it is my view that the situation looks most unpromising.

Therefore, since these considerations are so fundamental, anticipating that ballistic missiles can relieve the balance of terror between the United States and the Soviet Union is in my view totally unjustifiable, and no military policy decision in the near future can rest on the expectation of significant ballistic defense. Thank you so much.

## QUESTIONS

Mr. KELLY: Thank you, Dr. Panofsky. We are now starting the question and answer period, and -- Yes?



QUESTION: I have a question for both speakers. I've always been impressed with the confidence with which the supporters of SDI, in this case General Schnelzer and also General Abramson, have defended the SDI program. At the same time we have heard today a very effective presentation that objects to this program. My question to General Schnelzer is, how is it that you can maintain such a high degree of confidence when the criticism from such eminent critics is as strong as it is. The other question, for Professor Panofsky is: If the program is as flawed as you submit that it is, why is it a) that the Soviet Union seems to be pursuing a program of its own, and b) why is it that the Soviet Union apparently fears the effectiveness of our program so much? The third question, for both of you --

Mr. KELLY: Perhaps we should do one question at a time (laughter) --

QUESTION: May I just ask what defense you have against submarines?

Dr. PANOFSKY: Submarine based missiles, or submarines?

QUESTION: Submarine missiles right off the coast.

Mr. KELLY: Why don't you repeat your first question, to General Schnelzer, I believe --

QUESTION: Given the criticism from eminent physicists and others against your program, why is it that you are so confident that the program will work?

Gen. SCHNELZER: Good question, it really is. And what Professor Panofsky said, I think, is in a lot of instances true. Let me take a couple of issues there. We talked about the absentee ratio in the space-based interceptor; we talked about, I think, one to five per cent. We say that you're going to go against one field, one very small pocket, where they're going to launch an ICBM -- that's probably true, you'd have to equate what you've got overhead with what's below. But in actuality, out of military necessity, they're going to launch those missiles over a spatial extent that, if you look at the current distribution, it's a very large country and I believe it's very well populated by these missile fields. There are good reasons for doing that, because it makes it less susceptible to an offensive strike. So you have much more opportunity. Also if they space out the attack, timewise, -- this is a very dynamic structure; satellites in orbit are several kilometers a second and where it was one second, it's not there the next second. These things come into play. So you've got that opportunity. And we could go through each of these discussions, and they're very valuable discussions, believe me, they are -- they take us a great amount of time.

I think you really have to go back to historical perspective to really answer your question. Now if you take any of our strategic weapons, I don't care which one it is, if you take the ICBM when it was created in the late '50s, the bulk of the knowledgeable scientists and engineers would have been very pessimistic about our ability to do such. It was quite a demanding chore to put that together, but someone forgot to tell the folks they couldn't do it. Now I think that's what we see with

SDI today. You see all these bits and pieces, and -- we have an advantage within the program; we get to travel the country and get to talk to the scientists and engineers working the program, and we get to see the sum of the total, and it's remarkable, absolutely remarkable what scientists and engineers are able to see -- things that we thought not possible pop up every day, across the program. I mentioned the Delta 181 experiment, run by an Army major, flown in fourteen months. We haven't done that in two decades. We see that across the program. Talk about sensors that have been improved by a factor of ten -- we'd never have forecast that three years ago. And you can go on and on and on, and the bits and pieces are falling into place, they truly are.

As to the worth, right now we have no defense at all against ballistic missiles. Why did I show the one slide that showed the land-based component? It's because it's the only part of the strategic arsenal that has the potential and the capability to launch a pre-emptive strike and do that fatal damage in the very beginning. We can think of defenses against airplanes -- we don't have them today because we don't have any defense against missiles -- the Soviets do. You can make defenses against even submarines that sea-launch ballistic missiles, and there are some advantages in that arena as well.

But against the land-based ICBM, there is absolutely nothing. We see the promise that we can do something about it.

Mr. KELLY: I'd like to propose in this case that Professor Panofsky be able to respond to General Schnelzer's response, and then General Schnelzer will have the opportunity to respond to Professor Panofsky's comments in the spirit of fair play. Would you like to comment on that before your response --

Dr. PANOFSKY: Let me respond to the questioner first. Firstly, I do not object to the SDI project. That was not my position. My position is that I am objecting to basing any national policy, and the U.S. position on international agreements, on the technical promise of SDI. That is a very different statement. I believe it makes sense to do research and limited development of various kinds of the different methods of ballistic missile defense, if for no other reasons, to have the technology base on hand to see what the other side is doing. I have never seen a program, a military program, where the gap between the perception and politics, and the technical reality in the laboratory are as large as they are in respect to ballistic missile defense. I believe that many of the technical people who are doing first-rate work within the SDI program are very much troubled about the politicization of the issue and about the exaggerated prognostications which have been made. So it is not the fact that I am objecting in any way to the program. I am simply identifying the fact that advances in the state of the art which are necessary to achieve a meaningful defense of any kind are quite large and, considering the fact that defense budgets are limited, that one has to consider economic criteria. Namely one has to look at the objective, enhanced national security, and one has to decide where should the defense, the national security dollar go in order to do the most good. And it is by the economic measure, in view of Soviet countermeasures, that



I believe the expected results for SDI at the present moment are extremely low. That is my position. It is not my position that I'm objecting to the SDI program.

Next question is, why are the Soviets doing it? The Soviets have had an SDI program of their own for a very long time; they've had an air defense program which is considerably larger than ours for a very long time. They agreed in 1972 to limit their ballistic missile defense program as did we, and the Soviets are objecting to our pushing on the SDI program, although they have not in any significant way charged that we have exceeded the limit set by the treaty, and with the exception of the debated Krasnoyarsk radar, the Soviets have not exceeded their side of the ABM treaty. The Soviets have strongly objected because of the following fact: if you look at the build-up of strategic forces over the last decades, we have built up our strategic forces to the value of around ten thousand or so warheads in the 1960s or so; they followed, with a time lag of about six or seven years, so that we are now in a situation of approximate parity. The Soviets have major economic problems, so phase when the warhead re-enters the atmosphere. Most systems considered in the SDI program focus, as General Schnelzer indicated, on a multi-layer defense.

ABM/SDI type defense, data processing and sensor technology looms very large; this is something where we're ahead. On the other hand, they will make the necessary sacrifice to do so, and the result being that we will simply have a higher level of offense-defensive competitiveness; we will simply have elevated the competition to a higher level without an increase in national security.

And the reason why I think we should proceed with caution here is to not to adopt what one calls the fallacy of the last move, namely, when we take a step we should not assume that the other side will do nothing. It will take us a long time to deploy a defense of the necessary coverage to have any impact at all onto the strategic balance, and during that time the Soviets have a very large number of options. They can either build more missiles, proliferate the force; they can increase their, what we call, penetration aids -- that means decoys and things of that kind; they can shorten the burn time of the missiles and thereby deny us the option to do boost-phase intercept, and so forth and so forth. And if you wargame this thing back and forth, the situation simply does not look promising.

And this is no reason not to look at these problems, not a reason not to have an adequately supported research program on the basic technology which is involved and all that. And as I said before, I applaud some of the technical achievements which have been made within the SDI program.

But I strongly believe that it is wrong to base national security or political decisions on the potential achievements now. I think it is most unfortunate that in the Presidential debates the argument, "Are you for or against SDI," "will it work or won't it work," plays a role. That's a silly question. Will it work or will it not work makes no sense unless you define what "it" is, namely, which of the missions you are talking about. So I do feel that the SDI belongs in the laboratory, in the defense industry, in the test program; it does not belong, at this time, in a major national policy debate.

QUESTION: I'd like to ask both the speakers, how efficient is the ABM system deployed around Moscow, one, and secondly, do we have any countermeasures for dealing with it?



Mr. KELLY: General Schnelzer, would you like to try that first, and then --

Gen. SCHNELZER: If I replied to that I'd probably get in trouble.

QUESTION: I don't see why you should.

Gen. SCHNELZER: You'd get into some classified areas, of course. I'm sorry, I could not answer to that. I'd like to reply to that previous question, if I could --

Mr. KELLY: Well, let's go to Professor Panofsky responding to the question that was just asked --

Dr. PANOFSKY: The Soviets deployed a system of so-called what's known as goulash missiles, long-range exo-atmospheric terminal interceptors. They've put sixty-four of the interceptors around Moscow, and they had a number of large radars at various locations to provide the necessary guidance information. They then, about four or five years ago, they took those down and modernized the system by putting in a new generation of interceptor missiles which are rather similar to the shorter-range interceptors, so-called Sprint missiles, which were used in the U.S. safeguard system. So it is still technology which corresponds to around fifteen or twenty year old technology of ours. Clearly, there is no evidence whatsoever that they are exceeding the limit of one hundred interceptors per site given in the 1972 treaty. Since that only contains a hundred interceptors, it cannot shoot down more than one hundred of our ballistic missile warheads, and therefore, the consequence of this has been that presumably in our target list we have increased the number of missiles targeted against Moscow. So if I were the Moscow citizen, I would not feel any more or less comfortable by virtue of having that particular defense. But there is no evidence that the number of this next generation missiles, which they are putting in around Moscow, one hundred, that it is exceeding the number permissible by the treaty, and one hundred interceptors cannot down more than one hundred RVs, even though they have nuclear warheads. So I believe the military importance of their defense around Moscow is relatively minor; its main consequence has been, probably, I would surmise, a shifting in the targeting assignments of the United States by having a few more reserve missiles against Moscow. So I do not believe it's a major matter.

Gen. SCHNELZER: Professor, let me answer -- follow that up, because I think the premise of the question makes sense. If you deem the Moscow defense as defending against an American pre-emptive strike, I totally agree with the Professor. We'd have to get into classified data to talk about that. But think of the Soviet force structure today, go back to my remarks about how things have changed since 1972, and think about what the Soviets have done that we have not done -- they have put the three hundred plus SS 18s, again, a Peacekeeper equivalent, in the field since 1975; they've got a hard target capability. What's more they do something that we're not allowed to, and we wouldn't do: they operationally test those missiles. They actually conduct operations where they actually fire those missiles from

operational silos -- don't have to worry about environmental impact statements -- and actually exercise those in a wartime scenario. No one can predict how you're going to engage a war, in times of crisis. Take the Israeli middle east situation in 1956. If you think you're going to go to war, you're going to take the best defensive measures you can, and if all you've got is that arsenal which they do have, you can engage in a pre-emptive strike. If they did that, that Moscow defense makes a lot of sense. You mop up the residuals that would come against them. And they know that the only thing that's going to come against them quickly is the ICBMs, the subs take a while.

They've got a tremendous air defense. They've got ten thousand ground-based radars, thousands of interceptors, literally thousands of the most advanced Spiders, airborne defense against our bomber force. You know we don't have that quick response. If you look at our air defense, we have literally hardly any air defense radar, we've got a few squadrons here and there, mostly good reservists, but few, and it's a totally different force structure mix, strategy. In that sense, I think, you know, the Moscow defense does make sense. Also look at their civil defense. They don't debate civil defense in the Soviet Union -- deep, deep bunkers. You put the leadership, industry, support structure underneath the ground and you can survive. Make no mistake about it, their strategic force structures, whether for deterrence or not, is to fight a nuclear war. That's the way they exercise their forces. We do not.

QUESTION: I have a question for General Schnelzer. How can you be so confident that the SDI is worth spending all these many many billions of dollars, when first of all it has to work the first time. Secondly, it cannot be -- the whole system can never be tested. When we recall a few weeks ago, an American cruiser in the Persian gulf, with the latest fire control equipment, could not distinguish between an Iranian passenger plane and a fighter plane, when you recall the Challenger exploding in space -- mistakes are made. Human beings make errors. How can you have such great faith in this enormously complicated equipment?

Gen. SCHNELZER: Let me address cost first. SDI is a research program. The SDI budget consumes about one per cent, that's one per cent, of the DOD budget this year. And that's all. In fact, it's been consistently cut by the United States Congress, thirty per cent, every year for the last three years. If you look at SDI in the context of Apollo, it's about roughly a fifth to an eighth of what the Apollo program was. In terms of relative percentage it's not that big a slice of the defense pie or the national budget pie -- a tenth of one per cent of the national budget. In terms of testing, there is not a strategic system I know of, offensive system, that we have tested in the real environment. We have not fought a nuclear war, yet we build D5s, submarines, we deploy ICBMs, we build new bombers. Will it work when the time comes? No, the fog of war will be there. Will it work to an acceptable level? We talked about the tremendous devastation nuclear weapons will cause -- yes, they will cause a lot of devastation. Can we perfect it to a point that we can make it acceptable? Any death is not acceptable. But the point is we are in this dilemma right now, and it does add deterrence, and if something does go



wrong, at least you've got some measure of defense, but you have nothing, absolutely, today. It will be tested to best that we can test it.

You talk about the AEGIS cruiser that had that tragic incident in the gulf -- there were human mistakes that were made. If you look at that, and the Navy's going back right now, in fact I think they've published their report. Unfortunately, like it is in many cases, it's not so much technical error as human error, and how well you can use it. And they were in very special circumstances. If you know, they were fighting a surface battle just prior to that unfortunate incident. What can you say? There are new measures now that can be taken to prevent that from happening again.

Dr. PANOFSKY: I agree with General Schnelzer's reply, that neither offensive or defensive systems can be tested fully operationally -- thank God, if you wish. It is also true that the Soviets have great opportunity, by virtue of geography, to actually test offensive ICBMs from operational silos, although they cannot test them over the operational ranges, which they would have to test them for if they were directed against the United States.

But the main point which I was trying to make at the end of my talk applies really to the reply to those questions. In the nuclear age, the standards of performance which a defense will have to meet in order to have a major impact on the military balance has to be much higher than the standards which offense has to meet. In a deterrent role, therefore, a partial malfunction, a partial failure of an offensive system has generally less of military consequences than a failure of an anti-nuclear weapon defensive system. Now General Schnelzer is absolutely right, the Soviets have spent a great deal more investment, more money, in defensive measures within the constraints of the applicable treaty; there is no treaty which constrains air defense, and the Soviets have spent a large amount of money on air defense. Nevertheless, I believe almost all of General Schnelzer's colleagues in the Air Force believe that the United States bombers with air-launched cruise missiles, other stand-off weapons, can, with appropriate electronic countermeasures, with the appropriate penetration tactics, precursor missiles and so forth, can penetrate with large confidence, the Soviet air defenses. In other words, I would bluntly assert that the Soviets have spent their rubles poorly in having done what they did. I think in these debates one should not presume that because the Soviets have done something, that they have done it wisely and therefore we should do it too, which also makes a strong presumption. I believe the Soviet large investment in air defense is one of them, that the Soviets, similarly to other things, have done poorly.

QUESTION: I have a question. Would it not be useful for us to focus on efforts to withdraw both NATO and the Soviet forces from areas like Hungary, Czechoslovakia, eastern Europe and have more space between opposing forces? Would this not ensure peace and justice much better than the issues we are speaking about here?

Gen. SCHNELZER: If you look at the conventional force balance in Europe, as you know, it's one-sided. In fact the Soviet army in eastern Germany is larger than the entire United States army today, and one of the traditional ways we've had



to offset the conventional imbalance is with the strategic threat, if you will, the nuclear threat. That's been our premise since the 1950s. Now that we've, as the Professor said, had nuclear parity, *per se*, to some extent -- there's a big argument, you've heard our arguments today -- its impact on the conventional arena is decisive. People say that we have to spend a lot more money, and we'll have to spend a lot more money today on conventional means to maintain that peace in Europe. That is definitely part of the equation, and one that we might get into later on in this discussion.

QUESTION: I have a question that relates to Professor Panofsky's suggestion to put permissive action links on submarine launched ballistic missiles. One of the advantages of submarine launched missiles is that they're relatively invulnerable to surprise attack, and it's those warheads that we would have left over in the event of a pre-emptive strike, largely. Most people who worry about these things worry not so much in terms of the number of missiles that could be destroyed in a surprise attack, but rather the decapitation type of attack, the vulnerability there is perhaps even greater than in actually destroying the hardware. After all, the hardware sitting in silos is no good if you don't have any means of launching them. Isn't this a prescription for disaster if we did have a decapitation type of attack even if it were at all feasible to put these permissive action links on submarines. Putting it another way, there's a tension between the ability to launch nuclear weapons if you ever want to do so and means of preventing them from being launched accidentally, and wouldn't this tilt us too far in the direction of putting so many safeguards on the weapons that they could never be used if we ever wanted to use them?

Dr. PANOFSKY: Let me answer that question. Firstly, let me repeat, a permissive action link is a device which prevents the force in charge of the nuclear weapons from using it until a certain enabling code is entered, either through transmission of the code or by electromagnetic transmission of that code. There always is a tension between safety and readiness. If a force wants to be instantaneously ready, then the possibility of risk of unauthorized or accidental release is greater, and there is no way to relieve that tension, and obviously whenever one considers greater safety, by having permissive action links, in that case those concerned with readiness will object. When permissive action links were introduced in the tactical nuclear weapons in Europe, there were large objections from the Army, using just the kind of arguments you are making, that in case there was a sudden attack, or in case the chain of command was interrupted, they could therefore not be used, and therefore a decision had to be made about the balance between the safety and the unauthorized release or take-over by enemy forces, vs. the risk that they, in case of crisis, couldn't be used.

Now as far as submarines are concerned, there is of course some truth to what you say, but it is very naive to assume that the authority to release nuclear weapons resides only in person in the President. Obviously there are various obviously highly classified delegations of authority which make it possible to release nuclear weapons even if the President is no longer around. So therefore, whether a "decapitating strike," to use your words, would really prevent the release of nuclear

weapons by submarines, even if there were permissive action links, is a question which one cannot discuss here in detail.

**QUESTION:** My question is for the general. So far our debate has focused on Soviet intercontinental ballistic missiles and SDI's capabilities to destroy them. What can SDI do to destroy Soviet cruise missiles?

**Gen. SCHNELZER:** A good question. We do have a program, a sister program called the Air Defense Initiative, and if you go back to my earlier comments, we do not really have any real air defense capability in the United States today, or Canada, the reason being that without defense against ballistic missiles it doesn't make any sense to defend against bombers or cruise missiles. The mainstay of the Soviet force is in their landbased strategic missile. Definitely the first thing that comes in. That is the policy right now, that we really need to, if you will, be able to defend ourselves against ballistic missiles, which is much more difficult than probably even cruise missiles. Now we can get into the Stealth argument, the fact that you've got a hard time detecting and tracking, but even air-launched or sea-launched missiles have got to be launched by some thing, airplane or sub, and that's one attack. It is being looked at; it's being looked at with as much vigor as money allows.

**Dr. PANOFSKY:** I think the questioner has a good point. There is, as General Schnelzer indicates, a program called the Air Defense Initiative, which is a companion program to SDI, but its financial support is about an order of magnitude lower than that of the SDI. But as General Schnelzer's answer indicates, you have in the air defense situation also offense, defense, measure, countermeasure business, namely, if you do develop that air defense, then have the question of better penetration tactics and so forth and so forth. You have exactly that kind of thing, and the questioner is correct that one cannot examine the ballistic missile question in isolation from the cruise missile and stand-off weapons from aircraft and so forth and so forth, other defenses. Either you base your hope on such defense measures or you don't, and there is a certain lack of balance in the U.S. effort at the present moment, although indeed this companion effort, the Air Defense Initiative, is in being, is being pursued at a level which about ten per cent or so of SDI.

**Mr. KELLY:** I'm very sorry to terminate questions, but if either of the speakers have about a twenty-second urgent comment, it would be fine. If not, then, thank you very much for being here, thank you for your questions, and let us thank our speakers.



## Session Two - Economic and Strategic Implications of the Strategic Defense Initiative

Moderator: Dr. Kenneth W. Thompson

Speakers: Mr. John E. Pike

Dr. Keith Payne

Mr. PIKE:

Well, I've found over the last five years that the most frequently asked question about the Strategic Defense Initiative is: will it work? That's a deceptively simple question in the sense that there are a number of different ways to ask whether it will work. You can ask will the gadgets work? will the system work? does it work as strategy? and does it work as policy? Keith and I have debated this question a number of times, and I'm sure that he'll give you different answers to those questions than I do, but my conclusion after examining the Strategic Defense Initiative is that the answers to those questions are that the gadgets will work, that the system might work fairly well some of the time, but it isn't going to work perfectly all the time, and that SDI will not work as a strategy and will not work as a national policy.

Will the gadgets work? Well, I think the answer is obviously yes. To the extent that you define the problem as being "can you hit a bullet with a bullet?" We've been doing that for twenty-five years, so the question of can you intercept a single warhead or a single missile with a single interceptor, I think, is obviously yes. At the same time I think it's important to recognize that over the last five years, the principle area of technical progress that has been made in the Strategic Defense Initiative program is to identify those gadgets that will not work. The big problem that the Strategic Defense Initiative faced back in 1983 was that there were so many different gadgets that were under consideration for part of the strategic defense that the magazine illustrators had a terribly hard time cramming all of them into the picture that they were drawing of what a star wars system would look like. You had four or five different lasers clustered over in the upper left hand corner as part of the boost phase; you had four or five sensors floating around in the middle of space to track warheads in midcourse, and another big cluster of rail-guns and ground-based interceptors and radars and airplanes clustered around to intercept the warheads after they had re-entered the atmosphere. And the principal focus of technical progress over the last five years has been to simplify the magazine illustrator's task (laughter) by eliminating a lot of those technologies from active consideration. It's very clear that many of the gadgets that were originally under consideration in 1983 probably won't work. At the same time, I do think it is important to recognize that a small number of gadgets that are still part of the illustra-



tion of what SDI is going to look like, probably will work about as well as anything else that the American defense establishment produces. (laughter) That is to say, of course, that they aren't going to work quite as well as the artists' concept claimed, that they're going to take longer to build and they're going to cost a lot more than originally advertised, but I'm prepared to stipulate for the sake of argument, and because it's probably true, that if you give the contractor community enough time, give them enough money, and don't get your hopes up too high (laughter), that eventually they will produce things that at the gadget level are going to work about as well as anything else does. So will SDI work at the gadget level? The answer is yes.

Unfortunately, the problem is not hitting a bullet with a bullet, the problem is stopping a shotgun blast with a shotgun blast, because after all the Soviets are not going to be so cooperative as to throw warheads or missiles at us one at a time, so that we can shoot them down at our leisure, but rather the problem is to deal with a massive attack that consists of thousands of missiles, tens of thousands of warheads, and hundreds of thousands of decoys. And unfortunately, when you ask the question, will the system work, the conclusion has to be that it might work fairly well some of the time, but it's not going to work perfectly all of the time. To begin with, you're going to have a lot of trouble connecting the weapons to the sensor systems -- if you imagine the weapons as being the arms of the system, the sensors as being the eyes and ears of the system, obviously the critical element of the entire system is not the eyes, ears, or the arms, but rather the brain and the mind that is coordinating the whole process. Because if you don't have battle management hardware and software computers to get the information properly from the sensors to the weapons, then the entire system is obviously not going to work. And unfortunately the battle management problem for strategic defense is significantly more difficult than the battle management problem to be faced for any other weapons system. The amount of software is probably ten times greater than is being used on the space shuttle program, and clearly trying to come up with computer instructions to run the system, computer instructions that might be ten million lines of instructions long -- and that's literally an instruction book with ten million lines or perhaps a quarter of a million pages of instructions in it -- the notion that you're going to be able to write that quarter of a million page book without a single misplaced comma or a single misspelled word I think obviously indicates that the computer software you're going to be riding is not going to have the level of perfection that would be required for you to have absolute confidence in the effectiveness of the system.

Unfortunately while all of our computer programmers are frantically trying to tie the system together by writing reliable software, there are a lot of things the Soviets can do to undermine the effectiveness of the system. In addition to firing thousands of additional warheads at the system, they can fire hundreds of thousands of decoys at the system, and we're certainly going to have a very difficult time telling real warheads from decoy warheads. They can also directly attack the system itself; as the space-based elements of the system float over the Soviet Union, they can shoot at it with ground-based lasers, they can shoot at it with ground-based rockets. That's not to say that the computer software can't be written fairly reliably, and it's not to say that we can't do a fairly good job of discriminating real war-

heads from decoy warheads, or its not to say that we can't make the space-based elements of the defense fairly reliable, but it is to say that given all those difficulties, the system is obviously not going to work perfectly all of the time.

Which leads to the third way of asking the question, will SDI work? will it work as a strategy? and unfortunately the answer there, I think, has to be no. Because there are basically two types of ballistic missile defenses, those that work perfectly and those that don't work perfectly. And as former Secretary of Defense James Schlesinger pointed out, as a result of that there are basically two types of defenses: those that are feasible but not desirable, less than perfect defenses, and the perfect defenses that might be desirable, but are obviously not feasible. After all, President Reagan's original vision of star wars, the one the public has been so attracted to, is an effectively perfect defense, a defense of populations, a defense that would eliminate the nuclear threat. And recall what President Reagan was originally talking about was literally a defense where if the word came that a nuclear attack was in progress, then we would all be able to take our lawn furniture out into the backyard, pour a glass of lemonade, and watch a five-minute laser light show in the calm confidence that not a single nuclear warhead would reach its target. And I think to pose the problem in those terms is to recognize that whatever else SDI is going to do, it isn't going to do that.

Well, obviously, there are a lot of things that we could do with less than perfect defense of the type that we can build. We could defend our ICBM silos from a Soviet first strike. I have some difficulty understanding why it is that people have been so concerned about this so-called window of vulnerability and so concerned about the need to protect our ICBM silos, when you recognize that only about twenty per cent of our retaliatory forces are actually deployed in missile silos; the other eighty per cent of our forces are deployed on bombers and submarines that the Soviets clearly don't have any way to deal with. So I have difficulty understanding what it is the Soviets would hope to gain by attacking twenty per cent of our nuclear forces, recognizing that they can't do anything about the other eighty per cent of our nuclear forces, and knowing that this attack on our land-based missiles would simply make us very mad at them, without doing anything to reduce our ability to make them very unhappy in return. So I can't understand what the problem is with this so-called window of vulnerability, but for those people who, for whatever reason, seem to be worried about it, it's very clear that other alternatives, such as the Midgetman mobilized ICBM, are a way of closing that window of vulnerability much more quickly and cheaply than you can with the Strategic Defense Initiative. In fact it seemed to me to be very bizarre that the Reagan administration, which entered office complaining loudly about the window of vulnerability, has been so active in recent years trying to ban these mobile missiles, in what seems to be an attempt to keep the window of vulnerability open long enough that SDI will be able to come along at the end of the century and try to close it.

So I can't see that we ought to spend fifty billion or a hundred and fifty billion dollars trying to close this window of vulnerability. Maybe we could use a small star wars system to defend against a terrorist attack. Again, I have some difficulty understanding why we'd would want to do this, since it's very obvious that terrorists, if they really wanted to deliver a nuclear weapon to the United States, wouldn't do it in the one way that we would be able to deal with. It's obvious that they would



be much more likely to wrap it in a bale of marijuana and fly it across the Mexican border (laughter) -- they know that we wouldn't be able to stop them there (laughter).

So to review the bidding here: the gadgets are going to work, the system is not going to work perfectly but in terms of a strategy I can't figure out what SDI is good for. But my fourth question, does it work as a policy, leads me to the conclusion that not only is SDI no good, but it's actively bad. It's going to cost a tremendous amount of money, tens of billions of dollars to develop, hundreds of billions of dollars to deploy. It's going to further fuel the offensive arms race, because the most effective counter to a strategic defense is to simply build up more of the strategic offense than it can handle. If we continue in this offense, defense, spiralling arms race, it's very obvious that arms control is going to be a thing of the past. And without arms control and with the spiralling arms race, I think it's very clear that Soviet-American relations would deteriorate, tensions would rise, and the risk of nuclear war would grow. So I have to conclude that the gadgets are going to work, the system won't work perfectly, and star wars fails as a strategy and it certainly fails as a national policy.

Now Keith is going to give you a somewhat alternative view of the answers to these questions. Thank you very much.

Dr. PAYNE:

Thank you. It's genuinely a pleasure to be here today, the day before the big debate tomorrow. It's a good time, a propitious time to talk about this subject because defense, I suspect, is going to be an important election campaign issue. I remember with the debates last time around, in '84, there was an interesting comment that I heard, it was probably the funniest comment I heard; it was from one gentleman who said, concerning the debate, he would rather see Ronald Reagan asleep at the debates than Walter Mondale awake (laughter). I think this time around we probably have no fear that either George Bush or Michael Dukakis will fall asleep. The rest of us may (laughter) but I am sure that they will not. I hope today that this is at least interesting enough to pique your interest.

What I'd like to talk about are the strategic issues in regard to the SDI and strategic defense in general. By and large, the strategic issues are the most important, at least at this time, compared to the cost issue in particular. If strategic defense is a vital U.S. need, and if it's expensive, then that's probably still acceptable; if it's a vital U.S. need, then we should be willing to spend the money for it. If it's not a vital U.S. need, and it's inexpensive, we still shouldn't be willing to pay for it. So the priority question really is, how important is the Strategic Defense Initiative, and how important to U.S. security is strategic defense. And I'll pick up on John's thesis as to whether the SDI works as a strategy and whether it works as a national policy.

Let me first go back to the question of Will it work? and talk about that briefly. Will it work really depends upon what "it" is and what "work" means. How you define those two terms will, at this point, determine what your answer to that question is. If "it" is a limited defensive capability to protect retaliatory forces, I think that there's a fairly strong consensus that it would work, that there can be a ballistic missile defense capability that will work well enough to protect retaliatory for-



ces to a significant level of utility. And the value of that would be that it would deny the Soviet Union and any Soviet planners first strike options. Now the first strike options. I don't think, are very interesting for any Soviet planner, but that would certainly make them even less interesting than they are now. So the question, does it work if the "it" and the "work" means limited defensive capability to protect retaliatory U.S. strategic forces, for the purposes of deterrence, then we can fairly well say, Yes, it will work.

If the question is posed a little differently, if the "it" and the "work" mean a defensive capability to protect the bulk of the American population, that's a completely different question, a completely different type of situation, because then I think it's unclear whether it will work. We don't know whether that's possible, at least at this point. And the Strategic Defense Initiative is an effort to help narrow some of the questions about that. If it's for real protection of population, then the answer is not available to us at this point.

John likes to talk about the bale of marijuana surrounding the nuclear warhead as it comes in, and he's probably right -- it would be very difficult to insure that any type of terrorist attack or any covert action like that could be certainly stopped. On the other hand, any young Soviet colonel who goes to the Politburo and suggests that they're going to start a war, or engage in an activity such as putting a bale of marijuana around a nuclear warhead and flying it over the U.S. coast -- any Soviet colonel who suggests that as an actual option would likely be making little rocks out of big rocks in Siberia in short order. What we're talking about would be cutting out military options, and the Strategic Defense Initiative and strategic defense at this point fairly clearly could do that, if we decided to go in that direction.

But to look at some of the more important questions, I think -- as I said, the strategy question is now paramount, as opposed to cost and technology -- as to how useful, how valuable, could strategic defense be for the United States, and to really answer that question, we have to go back a little bit and look historically at where did it come from, why did the president propose the Strategic Defense Initiative when he did, and what was the point? So let me go back, circa 1980 to 1983, and recall very briefly what the context was. There was a freeze movement that was at least getting a great deal of political attention in the United States; it appeared that the deployment of any new U.S. nuclear forces, was going to be politically very difficult; the Catholic bishops had released a pastoral letter by '83 that was critical of U.S. strategic policy and several years later, in '86, the Methodist bishops released a letter that was even more critical of U.S. strategic policy. The poll data was showing that the American population was by and large very skeptical, to put it mildly, of any new U.S. strategic offensive nuclear force programs -- the MX ICBM, for example. So the Reagan administration had a problem; it saw that it appeared that the long-term trends did not look very good for maintaining strategic offensive deterrence, that is, the device, the mechanism, the policy that's supposed to protect Americans from nuclear attack. The Reagan administration, in effect, saw negative trends, political trends, in terms of the ability of the United States to maintain that deterrent. There appeared to be a decreasing credibility of the U.S. nuclear guarantee to Europe, a very sensitive issue, and it appeared that the United States needed to do something new, needed to do something different. It needed to change the ballgame to some extent away from its perpetual reliance on the

capability for mutual annihilation as the basis of your protection. Well, it changed the ballgame in a way that was less advantageous for the Soviet Union, and that would be advantageous toward the west, in terms of exploiting the west's advantages in high technology. It needed to do something that would not face the type of strict public criticism that continuing on with the nuclear competition seemed to pose.

Now interestingly enough, the SDI, I believe, is properly called the child of Ronald Reagan; he is the father of the SDI, but to some extent the antinuclear peace movement is the mother of the SDI (laughter), because had there not been such obvious and difficult trends in terms of the future ability of the United States to maintain a nuclear deterrent, it's not clear that the U.S. at high levels would have had to try and decide how do we change this ballgame, how do we move into some different direction that the United States can compete more effectively in. But the issue was, if we're not going to be able to maintain, or at least it's questionable whether we'll be able to maintain nuclear deterrence in the long term, what do we do? That question in fact is even more important today, I believe, than it was at the time it was posed, or at least answered in '83. With the INF treaty, the trends toward denuclearization that are very popular in Europe and here as well, with the prospect for a START I agreement, with significant reductions and the possibility of a START II agreement following that with even more significant reductions, with the extreme anti-nuclear movement that is in western Europe, and we must address in particular the question of what do we do in the long term to get out from this nuclear deterrent box that we are trapped in now, and how do we do that? Do we try and continue to maintain a capability for, in effect, annihilating military targets in the Soviet Union, which would lead to extremely high civilian casualties in the Soviet Union -- is that going to be the way the United States is going to try and maintain its security or are we going to try and change the game? The Reagan administration obviously answered that they wanted to try and change the game. And changing the game was, in effect, the purpose of the SDI.

Now with that, the question is suggested, how does the SDI fit into current U.S. strategic policy? If the game has been mutual capabilities for annihilation, how does the SDI fit into that traditional deterrence policy? The answer is, it doesn't fit very well. It doesn't fit very well. Obviously, if your basis for security and stability has been a mutual capability for annihilation, and the United States decides that it wants to change that situation, then that's not going to fit very well with the traditional policy, and it doesn't. But the question really isn't, how well does the SDI fit with the traditional policy of deterrence; the question really is different than that, it should be posed differently than that. The question that really should be addressed is, how does the SDI compare with the ongoing long-term trends? If we don't have the SDI, we don't have strategic defense, what is it that we're going to move towards? As I mentioned earlier, one of the reasons for the SDI in the first place was that the Reagan administration saw that the long-term trends for maintaining deterrence, strategic deterrence, did not look advantageous for the United States. So the question is, is the SDI a proper response to that longterm trend?

The U.S. deterrent is going to be increasingly difficult to maintain, virtually regardless of what happens. One reason for that is the broad-gauged Soviet defensive programs, the Soviet efforts. Remember what the Soviet Union does in terms of strategic defense, and I'm not talking just about ballistic missile defense or SDI



or star wars or starwarski or whatever the Soviet title for their program is. If you look at the broad-gauged Soviet programs for strategic defense, they are quite impressive. A fairly extensive civil defense, sheltering and relocation program; fairly impressive, in fact very impressive programs to burrow deep underground for the leadership protection that at least according to some official reports from the public does not permit the United States to threaten them for deterrence purposes. If you look at what the Soviet Union is doing, they are moving toward strategic defense, fairly gradually, but fairly effectively. Now you combine that particular trend with the long-term trend in the United States of facing more and more difficult problems with the U.S. modernizing its strategic offensive forces, and again you have to face the question, if we can't -- or at least it's questionable whether we can -- maintain strategic deterrence based on mutual annihilation; if it isn't clear that we can do that, then how do you respond, what do you do? The SDI was the Reagan administration's response.

Basically the way that I see responses to that question is that there are several alternatives. The SDI is one. Another is simply to try and maintain the traditional approach to deterrence that we had; in other words, we keep deploying offensive forces to counter their defensive deployments and their offensive deployments; they keep doing the same thing, and both sides in effect maintain mutual capabilities for annihilation. That in effect is what deterrence is all about, that's what traditional deterrence has been, what U.S. policy has been, and we can try to carry on that way. In fact, John mentioned one of the ways to do that is by deploying a small ICBM. The United States could do that. And that's in effect the answer that some of what I call the traditionalists are giving in response to the question about the SDI. Do you want the SDI? No. Why? Because we want to continue on trying to maintain an offensive-based deterrent. We're going to keep up with the past, in effect. Unfortunately, that particular approach has exactly the same problems that the SDI has, both technically and politically. Politically, as I said, it's very difficult in the United States to maintain strategic offensive modernization programs for the purposes of deterrence, extremely difficult. Financially it's extremely difficult. Technically, it's becoming more and more clear that coming up with technical solutions to maintain the U.S. deterrent is not easily done. Those technical solutions are not easily available any more.

And there is an additional problem with maintaining the traditional position, *i.e.*, that we will maintain deterrence forever and ever, amen, and that is that it ignores the fact that historically, deterrence has been a fairly unreliable policy. Because of a combination of leaders who miscalculate -- and they make mistakes, can be irrational at points -- deterrence should not be considered a completely reliable mechanism for maintaining nuclear peace that it has been. In other words your security, your protection right now is based on a continuing perfect functioning of deterrence, and unfortunately we know that deterrence historically hasn't functioned perfectly for very long. When I make that point, I often honestly get the response back that says, but we've had forty-three years of peace now after World War II, and doesn't that show that deterrence works and will continue to work. Deterrence may work, and it may continue to work, but recall that there were forty-three years of peace immediately before World War I broke out as well, from the end of the Franco-Prussian war to the beginning of World War I. And we know



that World War I broke out and escalated to a general war on the basis largely of misperceptions, miscalculations, misjudgments. What I'm suggesting to you is that deterrence, the traditional form of deterrence, of providing you security and protection is, in effect, not a clearly reliable means of providing you protection, because deterrence can fail. Historically we know that deterrence can fail, for all the different reasons that leaders can make mistakes, whether it's misjudgment, miscalculation, deterrence can fail. So the one alternative to the SDI that I call the traditional alternative, maintain deterrence, faces difficulties for a number of reasons, probably the most important of which is that historically we know that deterrence is an unreliable policy. And betting the future of this country and in effect betting the future of large segments of the world on the perfect functioning of deterrence is, I think, a very dangerous path.

There's a third group that in effect opposed the SDI for all the usual reasons that you hear: it's destabilizing, it's going to cause an arms race, et cetera. The problem with those positions is that they often don't suggest what it is that you're going to do. How do you solve the problem that the United States faces with regard to strategic deterrence in nuclear weapons, if it's not the SDI, and if traditional deterrence is at least questionable as to whether we would want to go in that direction, what is it that we're going to provide? How are we going to change the situation? That's really the question that we need to address. If not strategic defense to provide protection, then what?

We can argue persuasively against the SDI, based on a comparison of policies of the past decade, *i.e.*, we prefer deterrence over strategic defense. But that argument, I believe, is increasingly irrelevant. You have to compare the SDI and strategic defense with the trend towards the difficulty of maintaining mutual deterrence, and all of the problems you see posed to the SDI don't go away, in fact they stay. And if we maintain the traditional approach to basing your security on threats of mutual annihilation, we will have insured that a holocaust will result by, in effect, our own policy choices. And that's what I think the danger is, and that's why I see the SDI as a very valuable program that should be maintained, to determine whether there really is an option, perhaps combined with arms control, to reduce the vulnerability of populations to nuclear threat, and perhaps to reduce it to very low levels. Because the only other alternative is to maintain the traditional approach to nuclear deterrence, which is indeed a dangerous way to go into the twenty-first century. Thank you.

Dr. THOMPSON: Even with two very moderate and sensible presentations, our topic is obviously shot through with complexities and unanswered questions. One reason, it occurred to me in connection with the last presentation, is that there so frequently are intermediaries or layers in between, and I thought of a Mexican story to match the marijuana story: the FBI man had chased what he thought was a Mexican suspect to the border, and he challenged the suspect, but he knew no Spanish and the suspect knew no English, so finally he found a translator, and he asked, Did you steal the gold? and the Mexican said, Well, perhaps he did. He responded through the translator. The FBI agent asked, as he held a pistol to the head of the Mexican, Where did you hide the gold? And the Mexican said, he hid it in a well in the middle of the village, but the translator said, He says, Go ahead

and shoot! (laughter) And the problem with the political dimension is always that politics and the prediction of how one copes with the estimates that are made about the political future is just about as complicated as the problem of the Mexican and the FBI man. Who'd like to ask the first question?

QUESTION: Since we are talking politics, I'd like to ask both gentlemen to what extent they feel the work being done in the field of SDI was a factor in bringing about the INF treaty.

Dr. PAYNE: I think the more important factor in bringing about the INF treaty was the U.S. and European NATO deployment of the intermediate-range nuclear forces in western Europe. That undoubtedly was the key to getting the Soviet Union to come back to negotiations and eventually, in effect, adopting the U.S. position and coming to an agreement. The extent to which the SDI contributed to the INF agreement was probably important in the sense that it drove the Soviet Union back to being very interested in negotiation -- a clear case, self-expressed by the Soviets as such. They were coming back to negotiations by and large to get a handle on the SDI, but I think that in this case, the INF case, the NATO-U.S. deployment was undoubtedly more important.

Mr. PIKE: I think that SDI, to the first approximation, had essentially nothing to do with the INF agreement. If you look at the time line on it, the sequence was that Reagan announced SDI, and the Soviets broke off the INF negotiations; Reagan sent the SDI budget to the Congress, the Congress reduced the SDI budget, and the Soviets came back to the INF negotiations. So to the extent that I can find anything to correlate in those two fields, there seems to be an anti-correlation between the two. I think that the bottom line is that Gorbachev wanted to get Reagan's signature on an arms control agreement, and that the Reagan administration, despite its fundamental hostility to arms control, wanted to get an arms control agreement to defuse the arms control and national security issue in the '88 election, so there was a meeting of the minds that both leaders wanted an arms control agreement and the INF agreement was probably the easiest one to get.

QUESTION: I'd like to address this question to Dr. Payne. Sir, you kept referring to "our" safety, but yet you admitted that for protecting an entire population there hasn't been a satisfactory answer yet. I would like to ask you, doesn't SDI come down basically to the principle of deterrence, in protecting our capability of launching a counterattack on the Soviet Union?

Dr. PAYNE: The answer to the question is, at this point, no. Remember when I talked about whether "it" would work or not. One of the answers to that question is whether it's intended to protect essentially retaliatory forces, and that fits in with the category you suggested -- it brings it down to protecting deterrence. The administration is still, I believe, at least interested -- and you'll get debates as to how interested it is -- but there's still obviously interest in strategic defense as a means, ultimately, of providing protection that's much more thorough than the idea of simply protecting retaliatory forces. So I don't think that the SDI comes down simply



ly to protecting retaliatory forces; obviously in any near-term deployment, if there ever is deployment, if there is near-term deployment, it would in effect be primarily for very limited protection such as you mentioned. The long term should not be, and I don't believe is, considered with such a limited objective.

QUESTION: I have a question for Dr. Payne. I'd like to ask you to play the reciprocity game for a second, namely, if the Soviet Union announced an SDI program of their own with the same fanfare, what would have been the U.S. response to that.

Dr. PAYNE: Well, you don't have to imagine that, because in effect the Soviet Union had a similar program, and an even more all-encompassing program than the SDI going for probably twenty years, and by more all-encompassing I mean it wasn't limited to just the ideas of intercepting ballistic missiles. We don't have to imagine what the United States would do if we saw the Soviet Union moving towards strategic defense -- we know exactly what the United States has done as we've seen the Soviet Union move toward strategic defense. It's not as if it's an open question. It's a closed question because the event that you described has happened. The only thing they didn't do was announce it with such fanfare, which was probably very wise on their part.

Mr. PIKE: And I think that that's precisely the reason that the SDI program constitutes such a danger to the international situation, and why continued adherence to the anti-ballistic missile treaty of 1972, and clarification of what adherence to that treaty means, is so absolutely important. Because if you look at the thirteen or fourteen thousand strategic nuclear warheads and weapons that the United States deploys today, and go back and do a brief biography on each of those weapons, and ask why was it that each of these weapons was deployed, what reasons were used at the time to justify that deployment, it turns out that something like two-thirds of the strategic weapons we deploy today were at least in part justified on the basis of a perceived American requirement to respond to a perceived Soviet strategic defense capability. We put multiple warheads on our land-based and sea-based ballistics missiles, to discourage the Soviets from deploying an effective or an extensive ballistic missile defense system. We've deployed air-launched cruise missiles on our bombers because of concerns about Soviet air defense. We deployed the B-1 bomber because of concerns about Soviet air defense. We're now in the process of deploying the Stealth bomber and Stealth cruise missiles because of concerns about Soviet air defense. We've deployed new generations of ballistic missile submarines, and longer range missiles on those submarines, because of concerns about Soviet strategic anti-submarine warfare. I think that if there is any lesson to be gained out of the last forty years of the nuclear era, and certainly out of the case that Keith has referred to, it is that one of the primary drivers of the strategic offensive arms competition has been the perceived requirement to respond to the other side's strategic defenses. Secretary Weinberger has said that if we saw the Soviets deploying the type of ABM system that we're talking about in SDI that our response would be -- as it has been over the last three or four decades -- to build up more offensive forces, and that's precisely what the Soviets are saying.



Marshall Maksimov, the head of the Soviet strategic rocket forces, has been quoted on more than one occasion saying, not surprisingly, that the best response to SDI is going to be for him to be allowed to deploy more long-range strategic rockets. I think that at a time when both Mr. Reagan and Mr. Gorbachev have repeatedly reaffirmed that a nuclear war cannot be won and must never be fought, and at a time when we're at least beginning to reduce the scope of our nuclear arsenals, to go ahead with strategic defenses, or to build up those strategic defenses, recognizing that that's simply going to put more fuel on the offensive arms race, is moving in exactly the opposite direction.

Dr. PAYNE: This is an extremely important point; let me add onto that and just follow up a little bit, because it really is the key to an awful lot of the discussion about the SDI. I think what John just told you was absolutely correct, up until probably about 1984, 1985. In other words, if history stopped at '84-'85, I think John was roughly correct. But the point is that the Strategic Defense Initiative, the SDI, part of that is to no longer, as the transition notion goes, is to no longer try and prevent the Soviet Union from maintaining or achieving its defensive goals. What John said is true; the United States has been trying to pursue offensive nuclear forces to try and deny the Soviet Union its defensive objectives. In other words we want to keep them from being able to defend themselves. And that's what U.S. policy has been for a long time. As I said, up until about '84-'85, when as part of the SDI the notion officially endorsed as the transition took shape, and that was to change what John just spoke about, the arms competition that was based on the Soviets putting forth a defensive effort and the United States trying to respond to that to maintain its deterrent. And what the United States in effect said, and the president made it very clear, that the United States would in fact accept and even facilitate the Soviet defensive goals. The United States would no longer try and maintain its offensive nuclear deterrent, and deny the Soviet Union its defensive goals, as long as the United States could achieve its defensive goals as well. Now the point is that if you replace this kind of Soviet Union moving toward defense, the United States trying to stop that move toward defense by deploying its own offensive forces, it's very difficult to break that cycle. The only way that even conceptually it seemed possible to break that cycle is for both sides to be willing to allow the other side to achieve its defensive objectives, *i.e.*, the United States allowing the Soviet Union to move toward defensive capabilities, and at the same time reducing offensive forces so that each side's defenses can work more effectively. Now that in effect is, at least conceptually, the only way that I can identify that puts a stop to the cycle that John is talking about, which is why the SDI can be seen as very compatible and even necessary, I would argue, for deep offensive reductions as both sides move toward accepting the other side's defenses. That's something the United States hasn't allowed the Soviet Union in the past to pursue effectively, because we wanted to maintain our deterrent. The SDI tries to break that cycle that John just mentioned.

Mr. PIKE: I think that breaking that cycle has, in fact, proved to be so difficult that in fact it has not been broken, and that while the policy Keith is describing might be a sensible policy, in fact it's not the policy that the United States has been

pursuing for the last five years. Ambassador Nitze has articulated probably the clearest version of what our current policy is, the transition toward strategic defense, and his strategic concept does not speak of an environment in which defenses are dominant; it does not speak of an era in which defenses have replaced deterrence, but rather talks about moving towards a strategy in which deterrence is enhanced through additional strategic defenses. Now if the Reagan administration policy was one of taking all of the funding out of offensive modernization and simply putting it in the Strategic Defense Initiative, perhaps I might agree that the policy that Keith has outlined is in fact the policy that's guiding our government today. But if you look at the budget for strategic forces, this year we're spending something like four billion dollars on strategic defensive hardware and the SDI program, and something like forty billion dollars, ten times as much, on strategic offensive forces, and virtually all of the new strategic offensive forces that the Reagan administration wants to deploy are for pre-boost-phase intercept. The SDI is designed to intercept missiles after they've been launched; weapons systems such as Trident II, the MX, the Stealth bomber, the Sea Wolf new attack submarine, all of these are designed to intercept Soviet missiles before they've been launched. So I have difficulty believing that the relatively benign version of the Strategic Defense Initiative that Keith has painted for us is in fact the one that's guiding American government policy today.

Dr. PAYNE: Well it's clearly the case that that approach that I outlined was guiding the president's position at Reykjavik (laughter) -- it's clearly the case that the United States --

Mr. PIKE: Unfortunately his advisors managed to walk him back from it a few days later (laughter) --

Dr. PAYNE: -- and at the time the Soviets didn't agree in any case, but what I'm suggesting is that it's just simply not true that the transition that I talked about hasn't been reflected at all in U.S. policy. There have been some initiatives to achieve that kind of transition, and as John well knows, the United States could not simply, before an agreement was achieved, transfer all of its funding towards defensive forces and move completely out of offensive forces -- simply couldn't do that in advance of an agreement, because that would be very irresponsible thing to do, unless you know full well that this transition is going to bear fruit and flourish. So the United States simply couldn't do what John has just outlined as a means of moving towards a defensive transition. We shouldn't be surprised that it hasn't.

Dr. THOMPSON: We've been having a presidential debate as it ought to be -- the criticism of most presidential debate is that there's no debate, but here there has been. Are there a few other questions? Professor Fernbach?

QUESTION: Have you heard any rumors, either of you or both of you, have you heard any rumors about some economic pressures in the United States and the Soviet Union to curb the arms race at all, and is there any interest in this connection in making it into a matter of arms control? You both sideswiped that a bit,



would you address your attention to the linkage between economics, strategy and arms control?

Mr. PIKE: Well I would like to think that there was a very close connection between the two. I recall that the first time the Senate Armed Services Committee held hearings on SDI that Senator Goldwater's opening remarks included the observation that he was worried about the Russians and he was worried about the federal deficit, and that frankly he was more worried about the deficit than about the Russians. I think certainly if you look, for instance, at General Secretary Gorbachev's proposals on things like a joint expedition to Mars, that the Soviets are very clearly interested in doing something about converting our aerospace complex and their aerospace complex away from competitive undertakings such as the arms race and towards more cooperative undertakings such as the joint exploration of outer space. At the same time, I think that one has to be cautious in how far you take this, because there's no way around it, one of the reasons that we've gotten ourselves into this quandary is that nuclear weapons are very inexpensive compared to conventional forces. The reason that we continue to invest so heavily in them is that the alternative, of investing in conventional forces, is frightfully expensive, and unfortunately, we seem to have had much better success in arms control in the strategic and nuclear arena than we have in the conventional arena.

Dr. PAYNE: This is a point, to respond very briefly, that John and I agree on (laughter) (Mr. PIKE: Maybe I'd better clarify my position [laughter]) And if you do, maybe I should rethink mine (laughter). The economic pressures that the questioner mentioned, I doubt, press much toward nuclear disarmament or nuclear arms control, because in effect getting rid of nuclear weapons, to put it crudely, is likely to cost the United States more than it's now spending in national security, because if you pull out nuclear deterrents, in effect you're going to have to increase your spending on conventional forces to maintain the same level of security. Europeans know that, which is why they were quite upset, at least a large number of them, at the INF agreement -- you pull out nuclear forces, you pull out that deterrent structure, and what you have left is the need for a large number of conventional forces. So if you want to think about how to save money, the way to save money is probably not going about it through nuclear disarmament because that simply drives up what truly is the much more costly proportion of the defense budget, and that is conventional force requirements. Remember, nuclear forces take up about ten per cent of the Department of Defense budget for a year -- strategic nuclear forces. If you're going to save money, if that's the goal, then what you really need to attack is the need for conventional forces, not the nuclear force level.

Mr. PIKE: If I could clarify my point on that, very briefly --

Dr. PAYNE: Then we didn't agree --

Mr. PIKE: The concern I have is that in the past what we have seen is that new nuclear weapons systems are being justified as bargaining chips to help us get arms



control agreements; my concern is that increasingly arms control agreements are being used as bargaining chips to help us get new nuclear weapons systems. What we're seeing already under the discussions about the START agreement is that even though we're talking about a treaty that would reduce our forces by fifty per cent, actually the reductions are only thirty per cent and oh, by the way, this treaty's going to cost us a frightful amount of money because we're going to have to replace all of the weapons that are currently in our inventory. All of the discussion that you're saying about the START agreement is primarily focused on the fact that we're going to have to buy the Stealth bomber, that we're going to have to buy a new generation of ballistic missile submarines, et cetera, et cetera, so that the practical consequence is that arms control, rather than saving us money, is winding up costing us money. I have difficulty understanding why this is, and perhaps at some point someone will raise this question publicly, but the process is certainly not working the way it was advertized to work.

QUESTION: I wanted to respond very briefly to Dr. Payne in the form of a question: would it not be a satisfactory solution to the problem simply to build down nuclear weapons mutually rather than to build them up? And if we had time, I have some specific ways in which to do that by a process -- practical ways in which we can both approach something close to zero at the equal deterrence, and both be much more secure than we are now.

Dr. PAYNE: This is the Kissinger-Scowcroft idea, is it?

QUESTION: No, it's mine (laughter) --

Dr. PAYNE: The question is really good, because it responds directly to points I was making in my formal opening presentation. What you're saying is, isn't gradual or a process of disarmament an alternative to the nuclear deterrence bind that we find ourselves in. And that's a very good question. Let me respond first -

QUESTION: Before you like the question too much, the implication is that SDI isn't needed for this -- (laughter)

Dr. PAYNE: Let me respond and I think I'll address that. First of all, the process that you mention is probably the least important mechanism -- in other words, whether you get ten per cent per year reductions or thirteen per cent per year reductions on warheads or on throw-weight, the process really doesn't make that much difference. If you have the political will to do it, *i.e.*, to get involved in very deep reductions, the process will materialize. If you don't have the political will to do that, the process will be impossible. So often one sees a fancy formula for coming up with deep offensive reductions at the far end, they're very good and well and there's nothing wrong as a sort of intellectual exercise to come up with these different kinds of mechanisms, but the question really is, is there a political will to move in that direction, not what the process is. And to answer directly to your point, is that a solution to the nuclear bind that we find ourselves in, the answer

is no, not without strategic defense. And let me tell you why I believe that's the case, very briefly. Neither the United States nor the Soviet Union is at all likely to engage in very deep force level reductions, getting down to close to zero, I think was the number that you put forth, unless there's some mechanism for ensuring that if the other side cheats, it won't have disastrous consequences. One of the problems is, the farther down you get in the number of nuclear weapons, down to very low numbers, a hundred, two hundred, from the roughly twenty thousand that exist now, one of the problems is that the farther down you get, the more important would be those weapons that could be covertly put aside -- cheating, in effect. Even a few weapons that were covertly deployed, say a hundred or two hundred, if you're down to zero, or near zero, could make all the difference in the world as to whether the United States is again completely vulnerable, a society completely vulnerable to nuclear attack. Now there's no way that I know of, and I suspect that the general will concur, that we could actually verify a treaty that goes down to zero, whatever the process is. There's no reliable way of doing that. You could have an army of on-site inspectors in the Soviet Union, and you wouldn't know whether you'd gotten the other side to come down to zero or near zero. There's only one way that I can imagine of dealing with that particular fact of life, and that is by having a strategic defense system, even though a limited system, that could in effect cope with those covertly deployed weapons that we certainly wouldn't know about and the Soviets wouldn't know about. So in effect, the process you're talking about, deep offensive reductions, I believe, requires strategic defense to provide that safeguard against cheating that would become very significant at deeply reduced levels.

Mr. PIKE: Keith, we've got to stop meeting like this, because you're answer was half right. The other half (laughter) of it was wrong, but the first half of the answer was right. The fundamental question is one of political will. If there is the political will on the part of both sides to reduce the nuclear threat that each poses to the other, then you're going to get reductions in that threat. Absent that political will, you're not. If both sides agree that there should be reductions in the level of nuclear threat, then the most direct, the most expeditious way of doing that is simply eliminating the nuclear weapons. There are two possibilities here: either both sides could spend tens of billions of dollars in order to be able to shoot down a couple of thousand of the other side's warheads, or both sides could simply agree to get rid of a couple of thousand warheads that would be shot down by the other side's defense, and to keep the tens of billions of dollars to spend on something else. If there is the political will to reduce the level of the nuclear threat you don't need to go through the intermediate step of deploying a strategic defense to destroy the warheads after they've been launched; you can simply have an arms control agreement to eliminate the nuclear warheads before they're launched. On the other hand, absent the agreement to eliminate that level of nuclear threat, if one or both sides deploys strategic defenses, then the other side is simply going to add several thousand additional warheads to maintain the level of nuclear threat they need to feel safe. So you were right in the sense that the question is not one of methodology; the question is one of political will. But you were wrong on the question of why I need strategic defenses at the endgame, because it's precisely when I



get down to the level of being worried about only a small number of nuclear war-heads that strategic defenses become totally irrelevant and small planes with bales of marijuana become the thing that I'm really worried about. In a world that has gone to the point of being disarmed or almost disarmed, ballistic missile delivery systems are going to be the last thing that you're worried about, and it's going to be small airplanes filled with marijuana that's going to be the threat that you're going to be dealing with.

Dr. THOMPSON: If Dr. Panofsky promises to make his question very brief, and Payne and Pike promise to make their answers very short, we have time for just one more question.

Dr. PAYNE: I just want one minute to follow on to what John just said --

Dr. THOMPSON: But then he'll want one minute -- why don't you incorporate your follow-on in your response to Panofsky -- we don't have time.

Dr. PANOFSKY: The low point, I believe, of the last presidential debates was, Mr. Reagan said SDI will work and we will give it to the Russians; Mr. Mondale said, it won't work and we won't give it to the Russians (laughter) -- I have a basically fundamental problem of logic which are problems with Dr. Payne's remarks: basically both parties seem to agree that it is very dubious that SDI, or certainly not proven that SDI has any hope or expectation to give an area-wide population defense. Then Dr. Payne made the fundamental statement, with which I concur, that for very long range, to assume that deterrence is a stable basis for the security of the nation and the world is a very dubious proposition. But then he said, therefore we want to have SDI notwithstanding that both parties agree that the likelihood of it working for the population centers is very low. So it seems to me there is simply a logical hiatus there. The problem is if you go in that direction, you go upward in the direction of total deployment levels, rather than downwards, and since for me the key decision is that if you doubt that mutual deterrence is a durable, long-range proposition, then it seems to me the first decision you can make is whether you want to go down or you want to go up, and so I think there's a logical hiatus, and I wonder if Dr. Payne wishes to explain it.

Dr. PAYNE: I'd be happy to, because it allows me to get the point in that I was going to get in anyway (laughter) and that's in response to John's last point, but they merge nicely. John in effect said, why not just disarmament? Let's just skip the strategic defense part of the equation. If you have the political will for disarmament, then you'll get disarmament and we can skip SDI and the expense that SDI would involve. The problem with that -- I thought I pointed out previously -- is that you're not going to get the political will to go to disarmament, or even down to deep force levels, if neither side trusts the other very well. If neither side has a high level of confidence in the other, then neither side is going to be willing to go down to zero or any level approaching zero, because of the apparent dangers involved in the absence of strategic defense. Now if you have the trust -- if both sides trusted each other to go down to those kinds of very low levels, you wouldn't need the agree-



ment in the first place, because our relations with the Soviet Union would be at such a level of amity that we wouldn't even be talking about these things. So the problem with going to disarmament and skipping the strategic defense is that in that case you're skipping that mechanism which allows you to go down to the very low levels. That is what gives the political leaders the security that they would need in the event that the other side violates an agreement. And we know that in international relations on occasion parties happen to violate arms control agreements, so we shouldn't be shocked to think that leaders would be worried about that. So directly responding: you can't skip the midlevel, *i.e.*, that intermediate point of deploying strategic defense, because that's the only way the leaders are going to be confident enough to go down to deep offensive force level reductions. If you don't have that, you can't protect yourself from the possible covert deployments on the other side. Now with that let me add that you may not get deep force level reductions even if you deploy strategic defense -- on that point I think you're quite right. We know that we won't get there without strategic defense, and we may not get there with strategic defense. Now let me respond directly to the question of the hiatus in logic, because your starting point was incorrect: I did not say, nor do I believe, that it is impossible or highly dubious that the United States and strategic defense ultimately could defend the population. I am an agnostic on that point at this point. What it depends on is going to be how far we get, I believe, both technically and very much in terms of arms control, how much can we reduce the offensive forces of both sides to make the defenses more effective. So the reason there was no logical hiatus is because the first point that you mentioned was not my point, that it's highly dubious that strategic defense can provide population protection. I think that that remains to be seen, depending on technological developments and arms control developments.

Mr. PIKE: Keith and I agree that the resolution of the cold war and the eventual relaxation of tensions and amelioration of superpower relations is going to require our two countries to go to the movies. What we disagree over is whether we're going to see "Star Wars" or "Star Trek." I agree that some large technological undertaking is probably going to be an important element of ending the arms race. I think it would be much better for us to join our forces in some cooperative undertaking, scientific exploration of the solar system and the universe, rather than in some competitive and threatening undertaking such as the Strategic Defense Initiative.

Dr. THOMPSON: One of the vice-presidential candidates apparently made the mistake when he referred to members of the two opposing positions for the presidency as friendly critics. Today we have had ample evidence that friendly criticism can be restored to its original pristine meaning, and for that we thank our participants, and we also thank Reed Johnson and John Redick for a magnificent job in organizing this activity.

## Session Three - The Soviet Union and Strategic Defense

Moderator: Paul B. Stephan, III

Speakers: Dr. John Edwin Mroz

Dr. Stephen Neil MacFarlane

Dr. MROZ:

Just two opening comments before I begin the remarks. First of all, from my point of view, this is not a session on Soviet perspectives on SDI, but rather American perspectives on the Soviet Union and SDI. I certainly, for my part, am not here to explain or certainly to defend any of the Soviet positions on strategic defense. Secondly, and related, when I was originally invited to take part in this panel, I did assume that there would be a Soviet counterpart, who would precede me. So the nature of my remarks are considerably different than what I'd originally intended to present. What then I will try to do is to try to present a general overview of how SDI has been perceived in Moscow and what it means within the Soviet system. It is very difficult to explain concisely how the Soviets react to SDI, because SDI means different things to different people. I am not going to focus on Soviet positions on specific SDI components, that the General and others today have already outlined, but rather talk in broader terms about the way in which strategic defense is seen by the Soviet leadership.

We should begin by saying that the Soviets regard SDI not as a novel undertaking to reduce the risk of nuclear war, but rather as an extension of the geopolitical and strategic competition between the superpowers. Most Soviets agree that space technology is one of the most important areas of the overall superpower competition, and of course, as has already been pointed out, the Soviets have, for a number of years, had their own extensive research program in strategic defense technologies. When talking about SDI, Soviets distinguish between research and deployment. Whether you talk to Soviets from the government, the Central Committee, the military, or academia, there is a clear emphasis on this distinction. The concerns that I will try to summarize today are very much focused on the deployment phase. The deployment of an SDI system by the United States is perceived to symbolize a political and economic threat to the Soviet Union's standing as a superpower. It would virtually eliminate the possibility, in Soviet minds, for Gorbachev to succeed in the next twenty years with the goals of perestroika, that is, raising the basic standard of living in the Soviet Union and making the Soviet Union competitive in the next century. The economic dimension of SDI is perhaps the single most important consideration in the minds of the top leadership in the Soviet Union when discussing SDI.

But we should clearly understand that the Soviets are not afraid of SDI; some find it unsettling for a variety of reasons; others find it useful -- it has apparently



played a fairly important role in arguments that have been made within the Soviet leadership, for example, for resisting cutbacks in defense expenditures.

Let me comment first on the political, economic, and technological dimensions of how SDI plays in the Soviet Union. Let us begin where it all begins with the field of politics. SDI is seen as an effort by the United States to try again to achieve superiority -- to use American technological advantages for political reasons. I have not talked to any Soviet official or specialist contacts in any of my business in Moscow or elsewhere who believes that the United States has offensive designs and would attack the Soviet Union, but they do believe SDI could be a very powerful lever in the political battle between the two world leaders.

There are dozens of other arguments, and some of them are quite interesting. Let me just put a few out as a sort of smorgasbord. One of the most interesting is rooted in pressures within NATO and its existing U.S. alliances around the world. The SDI research program is seen by many Soviets in prominent positions as sort of a "21st century mechanism" to bring Japan, Western Europe, Israel, and the other top scientific and military talent into a new alliance with which the Soviet Union cannot compete. Even if not a formal alliance, such high-technology cooperation can only have negative repercussions for the Soviet Union. An ultimate nightmare for Soviet military planners and political leaders is, for example, that Japan, with its enormous technological capabilities, would join the NATO countries. I'm not sure of the latest statistics (that General Schnelzer can tell us) of how many corporations in how many countries around the world are involved in SDI, but the number is very substantial. The last I heard, it was in the dozens. Sophisticated conversations in the Soviet Union address SDI as a tool to unite the high technologies against the USSR. We rarely see this kind of an argument referred to in western assessments of how the Soviets perceive SDI, but it is a real threat for them, a way to form a "new alliance" for the next century, bringing what they call the best and the brightest of the scientific community to focus on the military sector and this not only for outer space, but conventional too.

There are more traditional Soviet arguments. For example, SDI is said to be a central obstacle to the concluding of any kind of significant strategic arms reduction agreements with the United States; the bargaining chip argument that we've already heard here today. John Pike mentioned a few moments ago that the Soviets argue that if the goal was truly to rid the world of nuclear weapons, as President Reagan said in Reykjavik, this approach seems to be an expensive and difficult approach. This is particularly true in light of the tremendous political changes that have taken place in the last three years -- the verification provisions of the INF, the withdrawal from Afghanistan, and a number of other positive and specific steps which the Soviet Union has taken which are meant, in fact, to begin to build a new trust with the U.S. And so Soviets do ask, quite seriously, why is it that we need to spend a trillion dollars for an elaborate system which might not work at all. There is very significant concern in the Soviet Union about the software, the data processing side of strategic defense system, where the Soviets are quite far behind us. Their concern is about malfunction, and those who know about Soviet technology and the reliability of Soviet technology, I think, can join in that concern.

There is evidence that SDI can be useful and has been used by some within the Kremlin leadership in a number of specific cases as a major argument against cut-



backs in defense spending. It is also used occasionally to show that the American threat is not totally dissipated as is now being reflected in Soviet polls, that the Soviet people do not see the United States and the west as a military threat. One way in which SDI has been useful for some in the Soviet Union is, in fact, to be invoked as a reason, this potential threat to the Soviet people.

Let us talk next about the economic aspect, which is another most important area for the Soviets who have long talked about the fact that the purpose of SDI, in its original conception, was to engage the Soviet Union in an accelerated arms race to bleed it dry, or to "spend the Soviets into submission." The Soviets admit that the Soviet economy is in a very serious state of crisis; not the kind of crisis where you can expect disintegration, but a very serious crisis. Most recently, those of us who follow Soviet economic writings quite carefully can see very interesting information becoming public. The Soviets' military spending over the last twenty years is now being estimated as twenty-five per cent of GNP. We hear all kinds of discussion now about the terrible problems of the infrastructure, the low standard of living, the unhappiness of the Soviet people; forty per cent of hospitals in the Soviet Union are said to have no hot water, or essential medical equipment; thirty per cent of the schools have no heat or sanitation facilities. Basically what you're dealing with in many, many aspects of the infrastructure is a third-world country. The people have been told, for seventy years, that they should do their best, to sacrifice, so that things will be better for their children, their children's children. That's a little difficult when you get to the fourth or fifth generation arguing the same thing. The economic situation in the Soviet Union is indeed serious, and the Soviets expect that the west would like to exploit it.

I belong to those who believe that the Soviet Union's economic difficulties should not be seen as an invitation for us to try to "spend the Soviets into submission." To achieve the goals of perestroika, which is the single highest priority for the Soviet leadership, and to meet the demands for a dramatic improvement in the basic standard of living of the people in the population means that defense expenditures must be reduced. There is no other possible way for the Soviets, especially in light of the declining price of oil and other economic realities. There is no other possible way that you can successfully deal with the expectations and the needs of raising the standard of living of the Soviet people, if in fact you don't have reductions in defense spending and defense priorities in general. The problems are endless. The stories we can tell are not just about weapons production and about military doctrine. We heard the other day of a story of several trains coming full of fresh tomatoes from a southern republic up to Moscow, and some military commander declared a certain area closed for a military exercise for a certain period of time. The trains sat in hundred-degree heat for two days. Campbell Soup could have started a manufacturing facility when those cars arrived in Moscow. This kind of event, the whole question of the priority given to the military, is now being debated at all levels of Soviet society. One can see for the first time, open criticisms of the Soviet military in Soviet newspapers and journals and magazines. This is not to say the Soviet military is happy with this; in fact there's very definite signs of their intense displeasure with this turn. It was one thing when the economic bureaucrats were being attacked in the press; it's quite another thing when the military and the KGB are also now being attacked under this glasnost period.

Let me move to some of the technological questions, to give you some examples of the kinds of things which concern the Soviets. The single most important fear under the technological area is the spin-off technologies which will be a result of SDI research. These could be much more significant than full-blown SDI systems. While I think that most Soviets that I've talked to, including leading military officers, believe that SDI itself, as a full-blown system, may never be deployed, they do believe that substantial chunks of technology may spin off that would be useful on the conventional battlefields of the future. For example, they quote American journals and military writings about spin-offs like miniaturizing electronic rail guns, whose ability to deliver hyperfast projectiles would potentially pose a grave threat to attacking tanks. Sophisticated Soviets who study this issue feel that the real purpose of SDI is in fact to come out with a massive research and development thrust into high technology, which can give the west an exceptional advantage, possibly tipping the scales in terms of the overall military balance, including on the conventional battlefield.

One of the interesting sidelights about SDI technologies is that we understand that the COCOM list of embargoed items the west can sell to the Soviet Union has in fact become the basis of Soviet prioritization of their own research and development. Some of these are hard for us to understand. The other day I was at Johnson & Johnson. One of their executives told me that their efforts to build a sanitary napkins plant in the Soviet Union was in fact being held up by the COCOM committee, because the technology used to make sanitary napkins is the same technology used to manufacture the insulating lining for jet fighters (laughter). This is something that -- oh, well, it's interesting (laughter). If you learn nothing more this afternoon, you've learned that (laughter).

There are many other arguments used by the Soviet Union. Ronald Reagan's offer to share SDI technology to assure mutual assured survival is certainly not believable. The way one senior Russian advisor to Gorbachev put it to me was that there's only two possibilities: either President Reagan is "dumb, which we don't agree to," or there's "something sinister and something more to this." The Soviets add that the impossibility of being able to test an SDI system under conditions approaching actual combat environment makes the whole thing, again, not sensible.

Finally, allow me to make a few comments about the military aspects. I understand Neil is going to talk about the specifics. Let me say that it's not SDI by itself. The issue is a combination of U.S. offensive modernization, including sophisticated conventional arms, together with space-based defensive deployments, and within a context of what they see as a U.S. war-fighting doctrine, that makes SDI potentially dangerous to the U.S.S.R. Virtually every Soviet you talk to, privately, those that you may have known for a long time, and who are quite critical of their own programs, reject the notion that SDI is strictly defensive. It's very difficult to find -- in fact, I have yet to find anyone who will argue that.

SDI is also seen as a challenge to stability, particularly in an interim period when both sides appear prepared to move towards a more defensive doctrine. The Soviets argue that the logical response for the Soviet Union to make to an SDI program includes a major offensive build-up of nuclear weapons. This comes at a time when their military, in a study which has been very controversial in the Soviet Union, has concluded that the nuclear winter theory is correct, and that one can-



not win a nuclear war, ergo, one cannot fight a nuclear war. Gorbachev and the senior leadership have apparently decided that the nuclear approach is not the way to pour defense money, that there are huge budgetary implications for new nuclear systems that will have to come in response to any deployed U.S. SDI system.

One of the most consistent and repeated Soviet perceptions about SDI is its role as an integral component of the pronounced shift of the U.S. nuclear strategy. This can be characterized as embracing the notions of a disarming first strike, a quest for damage limitation in the event of a nuclear war. These issues were discussed at some length at the meeting which Phil referred to in Budapest, when the senior operational military officers from the two alliances, including senior Soviet and American generals, as well as the Commander of the British Army of the Rhine, and the chief of staff of the U.S. Army in Europe, and others. They met together for three very interesting days on some of these exact questions. These kinds of subjects which I'm raising are the types of specific areas and subjects which the very senior Soviet military delegation raised during the course of those meetings.

There are other key issues for the Soviet Union in the military area, and let me just very quickly conclude. One is, of course, the whole issue of the possible effect on the stability of the military strategic parity between the Soviet Union and the United States, something about which there's now a great deal being written in the public domain. The question of the preservation of the ABM treaty and the ASAT ban, the prospects of reductions of strategic offensive weapons, and related to that, the prevention of new third-generation nuclear armaments; the economic losses to the civilian economic goals as a result of increased military competition, and the influence on the security perceptions of their own allies, and there's very good evidence that there is very significant difficulty now going on within the Warsaw Pact deliberations.

As my time has elapsed, let me just say that I personally believe it's not impossible to find a (*modus vivendi*) with the Soviets on limited deployments, mutual deployments, of what can be constituted as SDI component systems. I think, however, that this has to be part of a broader political strategy, as well as conventional arms reductions. Recently, in fact at that Budapest meeting, Volker Ruehe, who is the CDU defense spokesman in the Bundestag, surprised people by making a proposal on tank reduction which goes far beyond anything that has previously been discussed in NATO, and the fact that he is a prominent CDU Bundestag member has caused it to be taken quite seriously in NATO circles. This is the type of initiative we need.

There's a great deal that can be done. A final observation; much of the debate I've heard sitting in the back today could have taken place, I think, in 1985. We have to remember that there are serious changes taking place in the international political system, and, of course, major changes taking place in the Soviet Union. It is still definitely too early to determine what, in fact, will result from those changes, but I think that they should be perhaps more carefully integrated into the way in which all of us, in the American public, discuss and debate SDI and the merits of it. Thank you.



Dr. MacFARLANE:

I want to deal with three issues: the official Soviet response to SDI, the several aspects of the immediate rationale for this response, and finally, a number of the underlying factors that perhaps explain Soviet perspectives. Some of this has been gone over ably by Dr. Mroz, and so I hope to tread lightly upon them.

The official response, so far as I understand it (and I confess that specialists on Soviet policy in Southern Africa don't read this stuff terribly closely, so this is perhaps somewhat imprecise) is that substantial testing and deployment of the SDI would constitute a violation of the ABM treaty. It has been characterized as an element of a first-strike strategy on the part of the United States, and, as such a threat to peace and both deterrence and crisis stability. It is an impediment to the kinds of substantial strategic arms reductions that both sides purport to desire, and it constitutes a tendency toward the spread of the arms race to new environments, notably space.

With regard to the rationale for these positions, in each case there seems to be some credibility to the Soviet position. Many, such as Ray Garthoff and Gerard Smith, who participated in the negotiation of the ABM treaty, have held that the Reagan administration's broad interpretation of that treaty, which would presumably allow some substantial testing of SDI, is inconsistent with the intent of U.S. negotiators and policy makers at the time the treaty was negotiated, and with the negotiating record.

With regard to the issue of first-strike strategies, in the first place, there is some concern over the umbrella version of SDI, though how seriously anyone can take that in the Soviet Union is subject to question. To the extent that it is successful, the United States would be immune to retaliatory attack, and the deterrent effect of the Soviet strategic arsenal would be reduced to zero. If it were partially successful, it could substantially reduce the destructive effect and hence deterrent value of a Soviet second strike. After an initial American strike such a Soviet response might well be considerably degraded in effectiveness and lacking in coordination. There is concern also over point defense in this regard. A limited American defense might be able to neutralize Soviet retaliation after the Soviet Union had absorbed a first strike. The defense of silos and command and control facilities, moreover, would allow the United States to hold back an invulnerable strike capability for use should the Soviets be sufficiently foolish to respond to our initial attack. This is the window of vulnerability in reverse. In other words, the response after an effective American first strike, a disarming strike, would be potentially both ineffectual and possibly suicidal.

Along these lines, according to Soviet perspectives, point defense is detrimental not only to deterrent stability, but to crisis stability. Questions about the effectiveness of Soviet second-strike capabilities would presumably push the Soviet Union even further toward launch on warning, and ultimately to pre-emption in the event that they think that American attack was likely in a crisis. This, in turn, presumably, might drive us toward more precipitate use, since if we think the Soviets are contemplating pre-emption, we have an incentive to pre-empt that pre-emption. This has an effect on arms reduction negotiations, to the extent that the Soviets are worried about the effectiveness of the SDI, they will seek counter-measures. Perhaps the easiest of these is the multiplication of launchers and war-

heads. Arms reductions will impede the Soviet quest for cost-effective counter-measures, and this, I think, brings a certain reluctance to agree on an arms reduction treaty without substantial restraint on SDI.

Likewise, the deployment of space-based defense systems encourages the quest for means of attacking and destroying these systems. In other words, it favors an expansion in ASAT weaponry and an acceleration of the arms race in space. As such, it impedes efforts to render the arms-control regime in space more effective and may corrode the limited regime which exists already.

With regard to more profound reasons for pronounced Soviet unhappiness with the SDI, I think two subjects loom large, in my mind anyway. The first are military considerations, and the second are economic. I will deal with the economic aspect very briefly, since we have already spent some time on it. With regard to military affairs, the Strategic Defense Initiative may negate much of the Soviet build-up of the 1960s and 1970s. The Soviets expended great effort in catching up to a position of strategic parity with the United States. Subsequently they expended a certain amount of diplomatic effort to stabilize parity while not foreclosing their options for further development in the ICBM and SLBM fields. Effectively, to judge from much of the Soviet literature, they embraced the concept of Mutual Assured Destruction at the strategic level, based on invulnerable second-strike capability. Once they got there, in their view, the U.S. is abandoning Mutual Assured Destruction and launching off in a new and quite different direction. This could be construed, and certainly many Soviets whom I've spoken to on the subject construe it, as evidence of an American unwillingness to accept approximate strategic equivalence, and as an effort to regain superiority.

More cynically, perhaps, there is some evidence from the works of people like Marshall Ogarkov and General Gareev to suggest a transition in at least the military version of Soviet strategy to a view of strategic nuclear weapons as intrawar deterrents, devices usable for deterrence of strategic attack during war, a means of holding back American strategic response in the event of war in Europe. In other words, I suppose you could argue, strategic nuclear parity makes the world safe for conventional war in the European theater. And, arguably, there has been considerable Soviet effort in recent years to develop a conventional capability for this kind of option. The Strategic Defense Initiative, to the extent that it is effective, may destroy the intrawar deterrent quality of Soviet strategic nuclear weapons, negating this element of Soviet strategy as well.

Beyond this, and Dr. Mroz mentioned this in some detail, even if SDI does not produce the shield envisaged by the President, it may spawn new technologies usable in offensive operations. In my view, this adds an element of significant uncertainty to Soviet strategic calculations; moreover, as was mentioned, it plays to American strengths in the realm of microcircuitry, for example, and other advanced technologies. In other words, the Soviet Union is being forced to play on a field where, if I may mix my metaphors, the deck is stacked in the adversaries' favor.

In the economic sphere, it's reasonably clear that the civilian leadership, at least the Gorbachev component thereof, is uncomfortable with the idea of a substantial acceleration of the arms race. This would necessitate the devotion of increasing amounts of scarce Soviet R and D capabilities to defense at a time when that leadership's attention appears to be devoted to the quest for economic reform. In



part, the reform is of course based on a restructuring of the attitudes of the Soviet population, to render them more productive and efficient contributors to economic development. And there are also significant gains to be made from more efficient organization of existing Soviet resources. Moreover, many of the technological needs of the reform may be satisfied through joint ventures, and other means requiring Western technological inputs. But it is clear that to be successful in rejuvenating and redynamizing the Soviet economy, substantial new increments of capital and human resources are necessary to key sectors of the Soviet economy. Since the Soviet economy is growing slowly if at all in current circumstances, these resources are unlikely in the short and medium term to be generated through internal economic expansion at a sufficient level. In other words, the reallocation of resources is desirable.

It's clear from the Soviet literature that many Soviet scholars view the arms competition and in particular the recent American defense build-up to be substantial impediments to economic growth and restructuring. In a society strapped for factors of production, and where defense consumes, depending on who you read, somewhere between fifteen and thirty per cent of Soviet GNP, the military sector is an obvious target in the reallocation process, and there's again clear evidence from the literature that many are thinking in these terms. One can see this, I think, in the civilian discussion of reasonable sufficiency in military capabilities, and the growing volume of discussion on the problem of conversion of military resources to civilian use. The Strategic Defense Initiative, and the likelihood that it would be difficult for the Soviets not to respond with an acceleration of their own defense programs in this area, impedes the process of reallocation, not just in material terms, but because it will require the continuing attention of the country's best scientists and engineers to military problems at a time when their services in the civilian sector are clearly desired.

Now this is not to say that the Soviets are uninterested in pursuing SDI themselves in some form, but I think they would rather take their time and do it at a lower level, rather than being forced into an accelerated allocation of resources to strategic defense, which is uncomfortable given their current economic circumstances. For all of these reasons, I think that there's reason to take Soviet opposition to SDI seriously, and at least to consider whether the benefits from our perspective exceed the potential costs in our relationship with the U.S.S.R., and in the evolution of domestic politics inside that country. Thank you.

Mr. STEPHAN:

I have just a few brief points I want to add, and then we will take questions from the audience. I should have mentioned, and will mention now, that one of our speakers this evening, Steve Fought, did spend a week here this summer talking about SDI with Alexei Podberiozkin, so you might ask Steve this evening what he thinks Alexei would say. I just have a few observations. Just as a Sovietologist and entrail-reader, if you will, I have to note that the most recent promotion within the Soviet leadership, the most recent person promoted to the rank of Party Secretary, was the head of the Soviet space industry, and as far as I know, it is unprecedented for a space technocrat to be brought into the party leadership in this fashion, so that, I would read, at least, as a signal of how seriously they take space-related is-



sues, and I assume that this is SDI as much as it is anything, although not exclusively SDI.

More broadly, I come away from this discussion with a profession of a very profound dilemma that we face, and I would state the dilemma this way: on the one hand, we recognize that our situation with the Soviet Union is a kind of a, to use an economists' term, prisoners dilemma; that we are stuck in a mutually retaliatory game that could be solved better from both sides if we somehow could achieve cooperation. Breaking out of the prisoners' dilemma seems to be a desiderata. On the other hand, it is my sense from working with the Soviets for a number years now that they see reciprocity, that is to say, exactly the mutually retaliatory game, as extremely important -- that they find it very hard to understand anything except in terms of reciprocity and retaliation, and that theoretical point leads me to a concrete observation that I offer for what it's worth (which is probably zero), and that is, that any American president who seeks to negotiate away from SDI or more precisely to walk away from SDI has to take into account a cost from the Soviet perspective. It may be a cost worth over-riding; I don't mean to diminish that. And it is this -- that a unilateral reduction or elimination of the program will be costly to Gorbachev, and conversely, that a negotiation that ends up with the Soviet Union giving something up in return for American reduction or abandonment of SDI will strengthen Gorbachev's hand in the reform process going on in the Soviet Union. Now there are a number of leaps of faith involved in that assertion -- that Gorbachev is leading the reform process, as well as the belief that he faces competition from others who are opposed to it, as well as the belief that his hand will be strengthened by being able to have a successful negotiation. But I do believe all those things, and I will illustrate it and I will shut up with this point.

In a conversation with Alexeip this winter, with reference to a Soviet project that raises concerns under the ABM treaty, the Krasnoyarsk radar installation, his defense of that was that we've got these generals that are out of control; we understand that this is, a) a violation of the ABM treaty, and b) a technological dead end. That's to say, we don't think it's going to lead to anything. As John Rhinelander, the U.S. General Counsel to the SALT negotiations and co-author of the ABM treaty, was pointing out, we'd studied similar alternatives and decided they just weren't cost effective, but we can't control our generals. Well, if that assertion is true -- I don't know if it is or not -- what an opportunity for Gorbachev to eliminate some things that he needs to eliminate anyway, as part of a negotiation, as opposed to unilateral steps by the United States. We still have a fair amount of time for questions. Yes?

**QUESTION:** Yes, invariably, people have pointed at the destabilizing effects of the SDI as resulting in a most immediate reaction of increase in Soviet nuclear offensive missiles. What is your opinion, how do you see the other option, that is an increase in other forms of strategic weapons, such as the SS 21. Why does it have to be, seemingly, the ICBM hard launchers, why not some other option?

**Dr. MROZ:** First of all, the discussions in the Soviet Union on this subject are not restricted to the one option; there is a very very rich debate going on. We saw in the Budapest meeting very strong tension between the Soviet academic experts

and the military, on these kinds of questions. And it's clear that there's no decision. My stressing that point was just a sort of a bottom line. As I listen to the conversations, talking to people and reading what's coming out, that's the cheapest, the easiest, the fastest, the easiest way to deal with the problem. It is, also, I think, related to an understanding they have; that is, our public opinion, which they understand as a factor in all this, would understand that perhaps as easily and anything else, and so since we so emphasize that that is the primary threat to the security of North America --

QUESTION: When you say "that," you mean the use of the hard silo --

Dr. MROZ: -- hard silo ICBMs --

Dr. MacFARLANE: I agree; it's my impression that other options are being considered, but the simplest one, from the Soviet perspective, is the one in which there is so much momentum already, which is the hard silo ICBM. I wouldn't foreclose the the cruise missile route, as well.

QUESTION: I would like to see two poles pull together if we can in this situation. Defenders of the administration position have always, since 1983, emphasized a very large Soviet nuclear defense program. Of course they have in mind to a considerable extent air defense, and anti-bomber defense, and more ambiguous as to what they meant by antiballistic missiles. On the other hand, Soviet public statements since President Reagan's speech have taken a very strong position against Strategic Defense as a way of dealing with the nuclear threat, as if the Soviets did not have very substantial defense programs. So how should we integrate the Soviet position on this? They can't be as anti-defense as they sound when they're rebutting our emphasis on SDI. They are probably not as pro-defense as Weinberger and the defense establishment would have us think they are. How would you put the Soviet position together in this respect?

Dr. MacFARLANE: If I'm not mistaken, Gorbachev for the first time last year acknowledged the existence of a defense research program, focusing on defense against ICBMs. I think, however, that -- and it's probably true that that program is substantially larger than our program was prior to the initiation of SDI. From what little I know of the subject, that program did not constitute and does not constitute a substantial threat to the value of our strategic nuclear deterrent. It seems to me that they were happy to be going down that track, simply to be investigating alternatives, but to my knowledge there was no substantial commitment to fully test or deploy. I think they're quite unhappy about being pushed towards exploring it on the scale contemplated by the United States, which is a prospect they would have to take very seriously if SDI continues and there are some successes along the way.

Dr. MROZ: I would just add to that, if I may, that the general impression many of us get who have spent time over there with the military is the fact that they're going to let the U.S. call the shots on this; they're going to be prepared with dif-



ferent options on which way to go. It's partly a financial consideration, but it's quite clear to a lot of us that they're going to be in the respondent role, not in the initiator role. And I think that's the key thing; they're prepared for different things. They do have a much more difficult problem than we do, in terms of quickly reorienting research and other activities. We are much quicker at moving than they are, for a series of institutional reasons (laughter), which you can all imagine. Your question's a very good one, but I think it's impossible, I think any western specialist who sits and says This is what they're going to do, because we just don't know. There's a mix; they're prepared for different things, and I think that's the --

QUESTION: You're talking about them as respondents on this, and it's plausible that you're right. On the other hand, they have been for twenty years, thirty years, aggressive initiators in these other categories of defense, and it is at least odd that they would be so enthusiastic about air defense, and yet only passive responders to the United States when it comes to ballistic missile defense. Something there doesn't quite come together.

Dr. MROZ: Yes, but they see the overall correlation of forces right now, to use a Soviet term, as very unfavorable to their interests, events are seen as very much in our favor. You can go back ten to twenty years ago, and you will find the perception was considerably different. It's evident that the leadership has told them that they cannot have everything they want, in the defense budget -- the defense budget is no longer going to be of the magnitude, size, and growth that it's had in the past, because of the unrest and problems they have in their domestic consumer sector. Instability is increasingly likely from the internal, not external, factors. Obviously, anything can happen, and you're right to raise the point, but all the evidence I think right now goes the other way.

QUESTION: Dr. Mroz, I believe you made a statement to the effect that the Soviet military clearly subscribes to the theory that the nuclear winter theory is correct. Knowing a little about nuclear winter myself, I find that very hard to believe, in the sense that worst-case predictions of nuclear winter seemed to have been very much overstated and the current research indicates that while there is significant likelihood of climatic impact, it would be nothing like the apocalyptic premise initially. And moreover, it's quite a bit under the control of the tactics used, weapons, how they are deployed, season of the year, all that sort of thing. Doesn't this concern you perhaps that we may not know quite as much about the thinking of the Soviet military on such matters as this, perhaps other matters as well?

Dr. MROZ: Of course. And one thing we do know is there's been a tremendous debate going on for a number of years, first of all within the Soviet academic community, which picked up the nuclear winter theory, for example, and then between the academics and the military, which initially very strongly resisted it. What I did not say was that the military believe that the use of nuclear weapons is impossible. The computer study that was done (and we must remember that Soviet computers are not as sophisticated as U.S. government supercomputers, which recently are reported to have come to a less pessimistic conclusion as to nuclear winter) the



results of that study were of great concern to the Soviets. Chernobyl was also a factor; there were a lot of things that one can say went into this theory. But the concept of the freedom and ability to fight an extended nuclear war is something which I happen to believe no longer enjoys the support in Soviet military thinking that it did. None of us have information from the inside, but the nuclear winter theory seems to have become a factor in the political leadership's consideration of the issues.

Mr. STEPHAN: If I can add to that, I don't think anyone would assert that the Soviet technocracy, the informed technological people in the Soviet Union, have bought into the Carl Sagan version of the nuclear winter theory. What has changed, we believe, is that they now accept some version of the theory as opposed to completely rejecting it altogether, as previously.

QUESTION: I know that the military in the Soviet Union have been spending a lot of time inculcating the troops with the virtues of perestroika and essentially with the Gorbachev position. I wonder whether you gentlemen are familiar with the extent to which the military is divided over support of Gorbachev and his reform movement, and two, to what extent Gorbachev himself is in position to control the military at the present time.

Dr. MacFARLANE: I'll start. That's a very good question. There has been evidence of opposition and reluctance in military or quasi-military publications to accept military aspects of new thinking. I have in mind, for example, unhappiness with the tendency of civilian writers, the Kokoshins of the world, for example, to speak of reasonable sufficiency as a basis for Soviet military procurement and acquisition. In the military literature, at least until recently, this has been translated into defensive sufficiency, which is, I think, a consciously different term. When military writers define defensive sufficiency, they do so in a way quite different from the way the civilians define reasonable sufficiency. In discussing reasonable sufficiency, the civilians speak about non-provocative defense, for example, a concept presumably borrowed from the Green movement in West Germany. When military writers talk about defensive sufficiency, it suggests capacity sufficient to deliver a crushing blow on any aggressor, which is indeed more or less verbatim what Sokolovsky had to say on the subject of sufficiency in the 1960s.

That said, there does seem to be a gradual infiltration of civilian terminology and civilian ideas into the military literature over the past year. This suggests that moderates on defense issues seem to be succeeding in imposing their will.

On Gorbachev's capacity to control the military -- on the one hand, as someone trained in Soviet politics and foreign policy, I have difficulty in seeing how he could not. The entire nature of the Soviet state and its civil-military relations is structured in such a way as to insure that control. On the other hand, he doesn't seem to be very good at bringing senior military officers along to the degree that he might like. Look at General Yazov, for example, whom he promoted over -- what was it? twelve other people? -- to become defense minister. He was presumably a person whom Gorbachev found appealing when he went to Vladivostok. I guess he said the right things, because if you're in Vladivostok and you want to get to Moscow, and the

leader comes through, you say the right things. (laughter) But Yazov has since then criticized the civilian papers, including party papers, for slanders of the military. Yazov has an institutional perspective beyond his personal interest. That institutional perspective is one of opposition to civilian meddling in military affairs. There has also been criticism in the military literature of attempts by civilians to publish on questions of strategy, given their lack of access to military archives. If they saw the military archives, presumably they would have the correct view. There is a problem here.

Dr. MROZ: Just another point on that. At a recent meeting, one of the most senior Soviet operational officers, when he was trying to explain refinements in Soviet military doctrine under Gorbachev, clearly was instructed to talk "defensive" and nothing offensive. When he was asked by a British admiral to explain Soviet counter-offensive strategy, he backed off, saying "I can't talk about it, because we aren't offensive." The westerners responded that every defense has an offensive component -- was it the Soviet purpose to defeat the aggressor, or to defeat the aggression? It was very clear the whole Soviet delegation were unprepared to talk about counteroffensive doctrine.

The other point that you raised, which I think is a fair one, and should be explained, is the difference in the reaction of the military to perestroika vs. the reaction to glasnost. There is a significant difference; even Ligachev is not, as some people think, against perestroika itself. He is very concerned about too much glasnost (openness), and about the overall pace of the reform movement. Many in the military support perestroika's efforts to improve efficiency in Soviet industrial sectors, in particular, the infrastructure improvements which have long been of major concern to the Soviet military, that there is very strong evidence to show that some senior Soviet military leaders are in fact very dissatisfied that more has not been done, while others are very concerned about the pace of change which could lead to internal instability.

The real criticism from the military is on the glasnost side, and that is over the absolutely overt criticism of the military which is now beginning to appear in the Soviet press, including demonstrations and letters to editors of papers and magazines. The Afghan veterans, for example, are experiencing many of the same kinds of reactions which our Vietnam veterans experienced upon coming home. In fact, I understand in a couple of weeks, the first U.S. Vietnam Veterans group is going to Moscow to meet with the Moscow veterans of Afghanistan. The list of bitching and moaning by the veterans is dramatically similar, in terms of how they're being discriminated against in terms of jobs, and the public having turned against the war has led to towns that have voted not to put up memorials to the sons that have fallen in Afghanistan, and a host of similar actions that should ring familiar to the ears of those of us who recall the return of the Vietnam Veterans.

And this also goes for the KGB; we haven't talked too much about the KGB today, another small organization that has some influence (laughter), and they appear to have a similar concern about glasnost. We should, however, recall that the whole radical reform process started with Andropov, who was the KGB chief. We Sovietologists predicted that it was impossible for the head of the KGB to ever be-



come the General Secretary of the Soviet Union, and voila! Andropov. He is the reason why Gorbachev was able to do what he has done.

Mr. STEPHAN: We also said he was too sick, and we were right about that.

MacFARLANE: Could I just make one brief supplement, at the risk of appearing to be quintessentially academic in slicing things into ever finer pieces. There are really three things we're talking about here. One is perestroika; the second is glasnost, and the third is reform and strategy, and the implications of new thinking for the military itself. My feeling is that on glasnost, the opposition in the military is clear; on the question of reform of military thinking, the opposition is reasonably clear. On perestroika it cuts two ways, it seems to me. Obviously there is substantial military interest in improved general performance in advanced sectors of the Soviet economy, and doubt about whether the Soviet Union in the long term can maintain an advanced military capability in an economy which is, in Jerry Hough's words, not even competitive with that of Korea. On the other hand, I would think that people in defense procurement, who have jobs to do, orders to fill, are going to be quite leery about a restructuring of the allocation mechanism in such a way that they no longer have priority access to scarce resources. I think there's probably a lot of difference of view, even on the reform process. And also it strikes me that whereas it's intelligible that rational military officers faced with economic decline on the part of their state, would buy into a substantial reform, on the other hand, my impression of military perspectives, limited as it is, is such as to suggest that it is very hard to sell commanders on the need to take cuts, even in the short term, in dealing with the long term.

QUESTION: I'd like to know how you account, then, for all the initiatives having to do with defense, offense, military and strategic, are coming from Gorbachev. Seemingly, then, that there must be some coordination between the intelligentsia and the military, and some others.

Dr. MROZ: Not as much as some may think. Obviously Gorbachev is capable of acts of "strategic surprise" in his proposal-making. There have been a great number of proposals made by the academic community over a number of years, many of which have never surfaced in the political world, others which lie around for a while and suddenly get picked up and put into the General Secretary's speech. I think we can expect the Gorbachev style to continue, and as long as his power base remains, to continue to make bold proposals, particularly on conventional issues. I believe we should expect a series of more bold proposals. But I'm not so sure that there's the kind of coordination, maybe, implied in the question, of the sort of military/academic/political leadership --

QUESTION: I was just examining the evidence as opposed to --

Dr. MROZ: Yes, well, the honest answer is, we don't know.



Dr. MacFARLANE: If I might say a word or two about that as well. It seems to me that many of the initiatives in the nuclear area can actually be sold to the military, because arguably they are in the military's interest to some degree. For example, if you achieve an INF treaty which removes theater-based American deterrents of Soviet conventional attack, and leaves in place the conventional balance of forces, I would think that there are probably a fair number of generals who could buy into that. Now I think it gets really tough when you start talking about conventional force reductions and it seems to me that there have been a lot of interesting ideas on this subject mooted by the civilian leadership and in the civilian journals. From what I hear of MBFR in Vienna, for example, and the progress of conventional arms talks, or the non-progress, I should say, of conventional arms talks in Europe over the past couple of years, there's precious little evidence yet of any translation of that theory into practice.

Mr. STEPHAN: There's one other aspect of it that's really impossible for the Soviets to talk about with us, and which is completely out of our control to negotiate down, and yet it's terribly important to them, and that's the use of conventional forces for domestic purposes, and by domestic I mean not only among the Soviet republics -- remember, I began this by pointing out we are talking about Soviets, not Russians; but it is a Russian-dominated system, with lots of people who aren't Russians, who don't necessarily like the Russians -- but eastern Europe as well. And I think the next couple of years is going to be fascinating to see how much Gorbachev can keep it together when confronting articulated opposition from non-Russian minorities within the Soviet Union and from the non-Russians outside the Soviet Union in the Warsaw Pact. Thank you. Thank the panelists. Thank the audience. It's been very informative.

## Session Four - SDI, Arms Reduction, and Future Global Security

Moderator: Philip M. Nowlen  
Speakers: Colonel Stephen O. Fought  
Dr. Betty Lall

Col. FOUGHT:

My first name is Steve, I've got some time in the Air Force and that sort of thing, it's a pleasure to be back down here. The tasks of the last speakers always get somewhat complicated in the fact that we don't want to repeat what others have said, and we certainly don't want to necessarily contradict them, because you've already done a bit of that in the exchanges.

So I'm going to back up a little bit in some basic theory, and then try to go forward into what might happen with SDI, not just from a technical basis, but where it fits into national security policy. I think you will find out that I am generally in favor of SDI, and I would hope to tell you why; but I also have some reservations. I will also tell you about those.

Let me begin, then, at the very beginning. We're going to take what is called a top-down approach, and Don Neuchterlein was in the audience earlier -- Don writes about this all the time. Basically what we're going to do is look at what are the interests? What are the objectives? What are the likely strategies? Where does SDI fit into the picture? That's a blank viewgraph; that's because I never know whether I have to back up or go ahead. The interest is very simple: we're trying to defend ourselves, and if we screw it up we're all going to die, so the "interest" is quite easy to understand, since we're talking in nuclear weapons. So the next most interesting question becomes, What is the objective? Well, the objective is something called deterrence. Now here you become exposed to the fact that most of my undergraduate and graduate training is in engineering, and I ascribe to the thought process of a previous president, unfortunately not Jefferson, -- it was Andrew Jackson, who said, It takes a damn fool can only think of one way to spell a word (laughter). I will do the best I can throughout the evening, have no fear, but if there's something on here that is wrong, but that you recognize, please just keep that to yourself. If I blow it real bad, just holler, Hey Steve, I'll fix it, because my training has built a very large vocabulary of very small words.

The objective is deterrence. The question then becomes exactly what is it you want to deter? It's a legitimate question. There's a range of choice here. Obviously you want to deter (A) a nuclear attack on the U.S. by the U.S.S.R. You probably want to deter (B) a nuclear attack on your allies, meaning principally NATO, by the same party, the Soviet Union or the Warsaw Pact. You probably would like to



deter (C) a conventional attack on your allies, you might want to deter (D) a conventional attack by others on others; you might want to run the string out quite a bit further. There's a long range of choice.

The operative question here is, what do you want to use nuclear weapons to deter? And the United States has always answered the questions, that, yes, we use nuclear weapons for (A), yes, we use nuclear weapons for (B), yes, for (C), generally no, not for (D). The last case (D) is not where nuclear weapons fit in our foreign policy. The overall (A-C) concept is called extended deterrence, and it's very important that we define that and make a differentiation between that approach to nuclear weapons, and this approach, (A) only, which is called fundamental deterrence. Fundamental deterrence is the only thing that I would use nuclear weapons for in my foreign policy is to prevent a nuclear attack on myself, generally from my principal adversary. The U.S. has always been an extended deterrence nation. Deterrence extends geographically to other parts of the world, to Europe, and it extends philosophically to another level of conflict. It's a very complex concept.

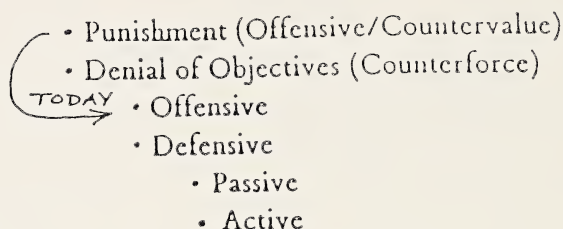
Now that we know what it is that we want to deter, we now begin to ask our questions: exactly how do you deter? Well, there's several ways. The first approach to how to deter is a punishment approach; it's very simple. You threaten to punish an adversary if he performs a certain action. You make the price exceed the possible gains. It's a very simple approach. If you're going to do that with nuclear weapons, it demands that you have a type of targeting called counter-value targeting, which by the way is usually called urban targeting or industrial targeting, or sometimes called recovery targeting. To paraphrase LeMay, that noted scholar (laughter), this is "Bomb them back to the stone age or make the rubble dance." "Punishment" is that sort of an approach. And by the way, you have to have offense to do that. You can't do it with defense. It also tends to be amoral and possibly immoral, if you go back and study just war principles -- it's not quite the conscious targeting of civilians, but it's not a conscious attempt to limit civilian casualties. So it's got some problems.

The second approach is denial of objectives. The way you deny an enemy's objectives is that you are able to counter his forces; he tries to do one thing militarily, you counter his forces. Very simple definition. The type of targeting there is military and leadership targeting. The two approaches differ in the very onset. In the punishment approach, you concede the objective; you just threaten to extract a ridiculous price in return. In denial of objectives, in its pure form, you would never concede the objectives, so denial of objectives is inherently more complicated; you would have to deny every objective from every avenue of attack. Fortunately there are many ways to do this. You can do it with offense; that's the way wars are normally fought. You attack in one direction, I counterattack in another, and I counter your attack. Or I can do it with defense. Under defense I can do it by both active and passive defense. With defense, I'm trying to blunt the effectiveness of your force. With passive defense, I allow the weapon to go off, I just diminish its effect -- examples are hardening missile silos, dispersal, concealment. Active defense means I don't let the weapons detonate; examples are air defense, probably SDI.

Historically, we started with a punishment approach; the other side didn't have any forces to counter, except possibly conventional, and we have gradually made a



### Mechanisms for Deterrence



### CHART 1

transition down to denial objectives by offensive counterforce, with a smattering of passive defense and very little air defense or SDI being technically precluded (Chart 1.\* That's how we're doing it now. So now we know what it is we want to deter -- (extended deterrence); and we know how to deter.

Now let's take a look and see how it's done today. This is a very simple chart (Chart 2). Basically what it is is the InterGerman border and U.S./NATO on one side and Soviet Union/Warsaw Pact on the other. Conventional forces oppose each other across the IGB in about that order of magnitude. The only point I want to make is they're stronger than we are, because that's what most of the studies say. We can argue all day on how much; just make it stronger for the sake of argument at this point. Behind those forces are what I have labeled INF or Intermediate Nuclear Forces, sometimes called theater nuclear forces again, and these are nuclear forces in Europe. I put those two at about the same level. Once you get up to ten, twenty thousand nuclear weapons, it's close enough for me -- we'll call it even. The difference, you might say, is in the noise. Strategic nuclear are behind them -- looking now at ICBMs, bombers, SLBMs and that sort of thing.

Here's the way the equation works (Chart 3). If the Soviets ever go first with a conventional attack across the InterGerman border (Step 1), at some point, because we have inferior conventional forces, the west is going to have to respond with its theater nuclear forces. As you'll note, some of the weapons are French; some of the weapons are British, but most of the weapons belong to the United States. A few of those weapons, now known in the popular literature as the INF missiles or the long-range INF (Pershing Two ground-launch cruise missiles) are U.S. weapons based on European soil which have the capability to reach the Soviet Union. So to us they may be theater; to the Soviets they are strategic. If those are the weapons used (Step 2), then it is likely to assume that the Soviets would respond with strategic systems back to the United States, (Step 3); and if that ever happens

\* Colonel Fought's presentation was dynamic and he used the overhead projector like a chalkboard. We have made our best effort to capture and recreate his charts and their flow.

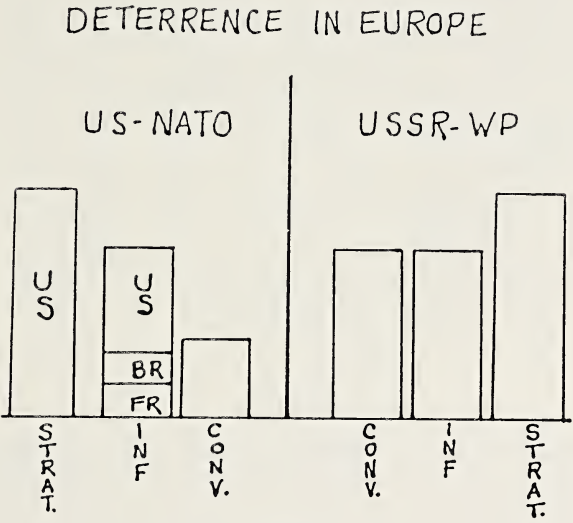


CHART 2

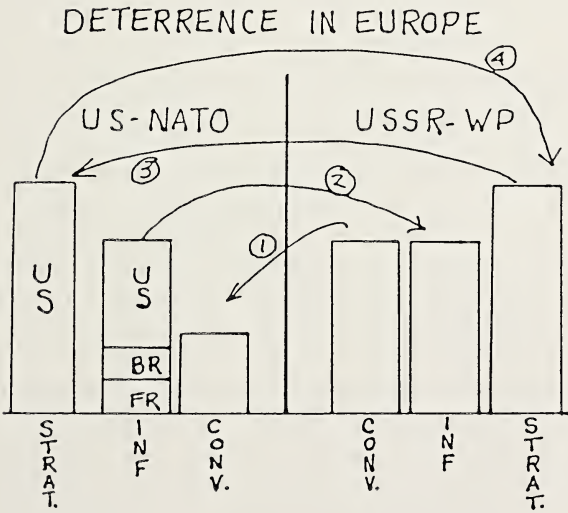


CHART 3

## DETERRENCE IN EUROPE

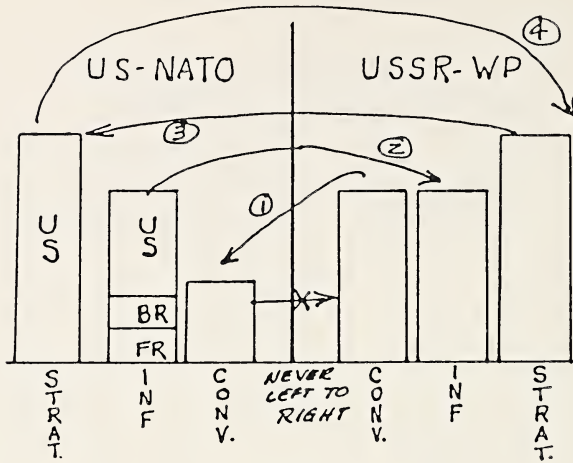


CHART 4

there is no doubt that the United States will respond with its strategic nuclear systems back to the Soviet Union, and (Step 4) there's a central system nuclear exchange and everybody dies.

Now you may not like that policy; you make think that's an ugly policy; but that's the way it is. The whole logic is that if you cannot afford what's at the end of the road, step four, a global holocaust, you never take the first step on the journey, Step 1, which is conventional aggression in Europe. We thereby extend the nuclear umbrella over Europe and use the threat of a central system exchange, or terminal escalation, to prevent conventional aggression and that is extended deterrence. The linkage forces are the INF.

Now we think we can do a couple of other things with this diagram. First, I think we can guarantee to the Soviets that the arrow never goes in that direction (Chart 4). There's a long history of ground combat in Europe and we know that it takes superiority of the offense over the defense in order for the offense to succeed. The defender has the privilege of preparing his terrain, of fighting on his own territory, and of using interior and in fact collapsing lines of communication and supply. The offender has exactly the opposite problems, and it gives the defender the advantage. If you have inferior offense to begin with, it provides physical evidence that you cannot go on the offense, and this is a very important part of NATO strategy. What Nixon sought to do was to add this concept of mutual deterrence to the arms race -- and I call it mutual because we are deterred from going on the offense. We do not mind being deterred; we have no territorial ambitions. We do not mind being deterred by the Soviet Union as long as we can deter them, so mutual deterrence is quite acceptable. We sought to stabilize the relationship there, and had an objective of a rough balance of forces entering into the SALT I agreements. What that does is it changes the objectives from just extended deterrence to stable mutual extended deterrence, all as defined so far. Stable means "sort of": Buy the forces once and for all, put them in place, and walk away from the problem, so that you don't have to keep pouring money down a rat-hole, literally -- spending money on



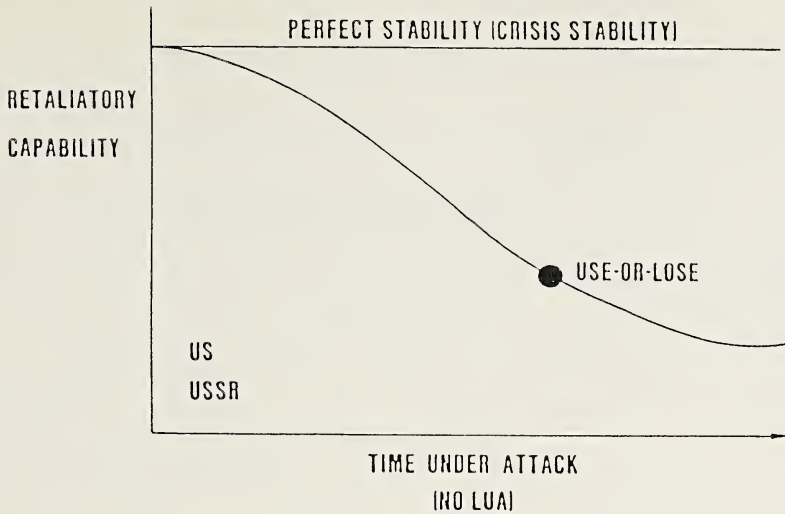


CHART 5

things that people can't eat. Very few people are capable of consuming a nuclear weapon. Spend your money on something else.

Now stability demands a far more rigorous definition than that, and I'm going to offer you one now (Chart 5). It means, roughly, your retaliatory capability -- I already told you about my spelling, so r.e.t. is all you get -- it's a RetCap, that's retaliatory capability -- measured over time with time under attack -- T zero meaning no attack, time proceeding out here, meaning you're under attack, and the underlying assumption is that I never launch; I have to be able to ride the thing out. If my retaliatory capability were a constant over all time, over literally all situations that I could think of, I would have perfect stability. It's often called crisis stability, by the way, but I'll call it "perfect" here and I'll put "crisis" in what ever those things are.

Now, as pointed out by several of the discussants today, that is not how the world looks. The Reagan administration saw in the early 80s a window of vulnerability; there was a decay in the U.S. retaliatory curve to a point where, under attack, the United States would eventually be so squeezed down on its retaliatory options that it would have to either use the options (on large scale, by the way) or capitulate -- the use or lose phenomenon (Chart 5).

Now, you cannot allow the other side to calculate that they can do that to you. Perfect stability means no incentive to go first. You have to solve this problem. You've got to push this use-or-lose point up and away as far as you can; there's three ways to do it (Chart 6). First of all, you can build more strategic offensive forces -- just build some more weapons, build more offense. We know how to do it. What you're doing is you're buying some insurance, so you add at time:zero this much, and you add about yay many, and if nothing else in the world changes, the world is more stable to the degree that you add -- you're just bumping the curve over. It's not a bad solution; we know how to do it; cheap too.

The second way is to negotiate, to enter into a negotiation with your adversary, who now becomes a partner, and identify the difficulties in this. Then, the degree

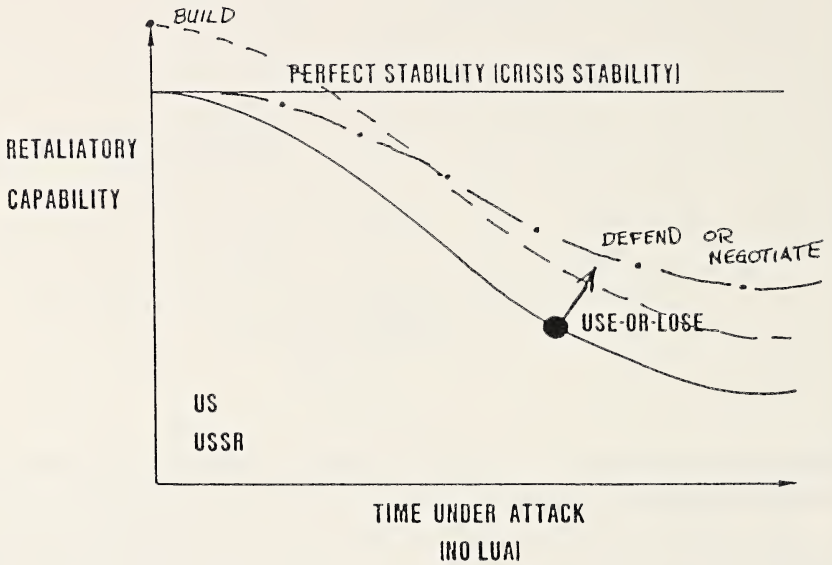


CHART 6

Mechanisms for Deterrence

- TODAY →
- Punishment (Offensive/Countervalue) URBAN, INDUSTRIAL
  - Denial of Objectives (Counterforce) MILITARY, LEADERSHIP  
(SOVIETS VALUE THEIR MILITARY & LEADERSHIP)
  - Offensive
  - Defensive
    - Passive
    - Active

CHART 7

to which you eliminate them through negotiation rotates the curve, and makes it more stable.

The third way to do it is to defend. Defense works just like negotiations -- to the degree to which you defend the forces the curve rotates up and it becomes more stable.

The problem here is that there are two of these curves. I talked about the one for the U.S. Because of that word mutual, there is also one for the Soviet Union. Now if I choose to resolve the decay in my curve by building strategic offensive forces in a manner that causes a decay in the Soviet curve, then the Soviets have a right to -- or certainly can be expected to; we can argue whether they have a right -- to correct the decay in their curve. If they correct the decay in their curve in a manner that causes a decay in ours, then I correct my curve, and bang, bang, bang, you get going back and forth, you have an arms race.

Really you've got two kinds of stability -- you've got crisis stability, which is the degree of flatness of the curve, and you've got arms race stability, which is something like a first derivative -- it's the way you keep stability going, or it keeps bouncing up and down. Ideally you'd have crisis and arms race stability. That would really solve the problem of being able to buy the forces, walk away from them, et cetera. But when you can't solve a simultaneous set of equations, you have to pick which variable dominates. Now suppose I had crisis stability -- just keeping the curve flat -- but I was doing it through an arms race, bouncing up and down by proliferating weapons. That's not a good solution, because I'm spending money; money that's better spent elsewhere. But suppose I have the opposite, that is, crisis instability with arms race stability -- in other words, I'm not spending money on arms, but these retaliatory curves are starting to decay. In that situation, in a crisis, there is an incentive to initiate a strike, and here you consume whole societies. There is no choice. You go for crisis stability; you resolve the basic problem, and you get what you can out of the arms race, but you seek a simultaneous solution, because the simultaneous solution is the objective.

Now within all of this, what's SDI? When President Reagan took office, with this window of vulnerability argument in being, it was quite obvious that building strategic offensive forces was going to fuel the arms race. If you go back to this chart (Chart 7), we have said that you must hold at risk what the Soviets value most -- that's their military and their leadership. This is the type of offense that we have to build. Offense that is capable of a counterforce strike is also first-strike offense. I can sit here and tell you all day long that I won't use it first, but you have got to calculate otherwise. The Soviets said the SS 18 is not a first-strike weapon. I have got to calculate otherwise. How do you build a counterforce offense without building a first strike? You can't. The two are the same, and they appear the same to both parties. So what the president was looking at was the fact that continuing to build weapons would drive us in the wrong direction. Negotiations, in the mind of the man in the office, had failed miserably -- the term is fatally flawed, for a variety of reasons. He turned to the scientific community and said, Let's open the other door -- defense. And it's a reasonable thing to say, "Let's investigate it" -- hence we have the SDI speech (Chart 8).

Now where does SDI fit in the basic theory? It fits in the basic theory here (Chart 9), and it should be seen as an attempt to change the way that we deter, from



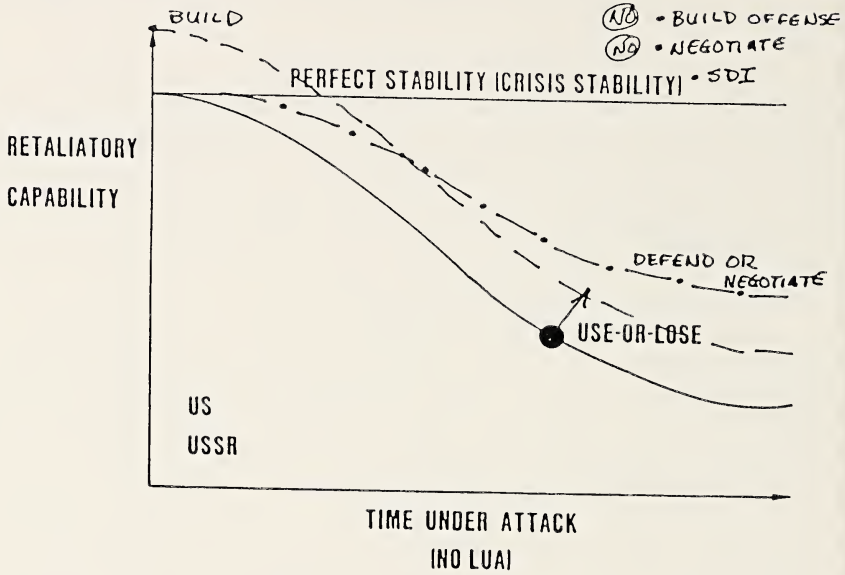


CHART 8

### Mechanisms for Deterrence

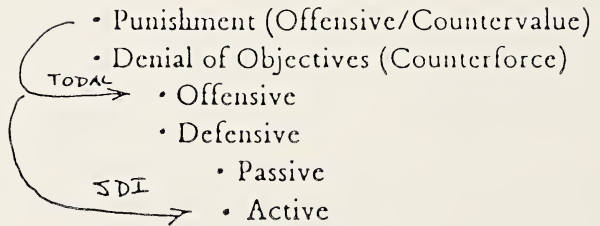


CHART 9

denial of objectives by counterforce offense to denial of objectives by active defense. It is that and it's nothing more. Critics have argued that SDI replaces deterrence; it does not. SDI changes the way that you deter; it does not change the objective. In fact, that is what makes SDI so complicated. You have to maintain the objective in all of its parts. It has to be stabilizing if it's going to satisfy U.S. policy, stabilizing in that it can't fuel an arms race and it cannot provide an incentive to go first. That's what meets policy guidance. It must preserve the mutual aspect in that it cannot be seen as an attempt by the U.S. to gain superiority or to somehow gain an initial advantage. It must still provide for extended deterrence; that is, it cannot defend us and it cannot protect us and it cannot isolate us from NATO; we must continue to protect NATO. And finally, of course, it must deter. It must prevent the things that we said. Had we wished to change any of those objectives, or the President or SDIO wished to change any of those objectives, SDI becomes simple, but the fact is all the objectives are operating.

Now what I'm going to do is to start building you a simple -- simple? Hah! -- I'm going to start building you a picture of what SDI might be, and I'm going to relate it to this term stability, because that seems to be the crucial variable. I'm going to start with a simple box (Chart 10), and I'm going to measure stability by the total number of Soviet weapons that can reach the U.S. measured against the total number of our weapons that can reach them. That is an imperfect variable; it's a surrogate; it's a proxy. I understand that. But it'll do for now, because we'll make it more complicated as we go.

When I'm plotting the total number of weapons each side can deliver to the other, the first block that is of interest to me is a block that is normally called "minimal deterrence" -- min det (Chart 11). It's usually associated with the early MacNamara concepts which are sometimes called massive retaliation, four hundred to six hundred weapons, large dirty weapons to destroy fifty to seventy-five per cent of the Soviet urban population and industrial capacity. It's not very many weapons. You can call it inflation, the fact that the Soviet Union's a much larger place, now call it two thousand weapons rather than four hundred to six hundred. The point is, it's nowhere near the number of weapons that we have now. This is a very small block on our diagram. Most people will argue a minimum deterrence approach, by the way, or the minimum deterrence number of weapons, this four hundred to six hundred or maybe as high as two thousand, is only good for fundamental deterrence, and that's only protecting yourself. You can't do extended deterrence with it. But we can argue that later.

The next block that is of interest to me is a block that I shall choose to call the zone of SALT I (Chart 11). Now SALT I is an absolutely fascinating period in the negotiation, the relations. First of all, all of the weapons were thought to be of the stable variety. Now by stable, I mean, prompt counterforce doesn't exist, so nobody can have their weapons taken away from them. The first two tenants of this zone, the first two assumptions of this zone, are as follows. First, both sides seem to have agreed that they either had at that moment or soon would have too many weapons. Otherwise, they would not have agreed to reduce. The second is, their weapons could never be taken away from them -- flat retaliatory curves, if you will. If you have too many weapons, and they can never be taken away from you, you ought to be able to reduce. That's reasonable logic. It's incomplete logic, though. You have

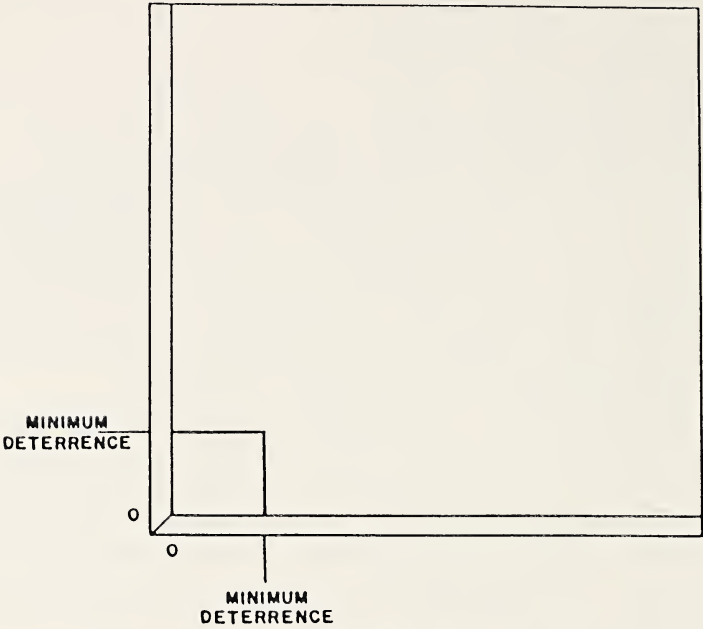


CHART 10

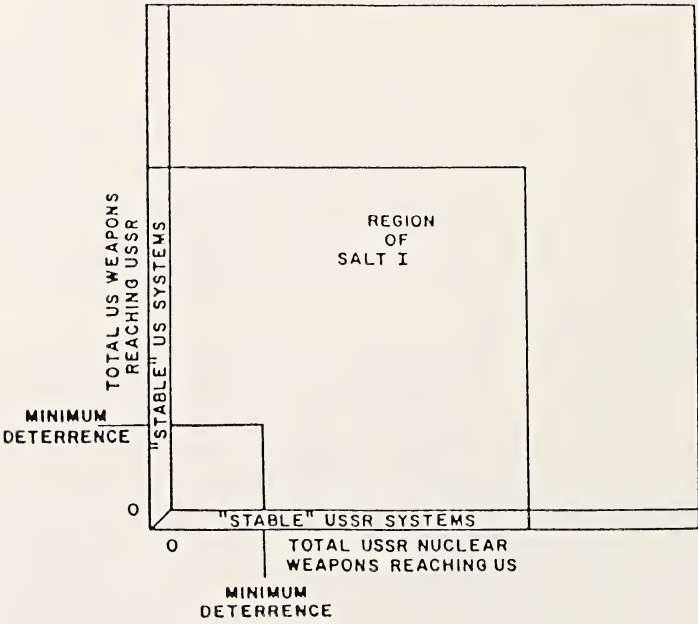


CHART 11



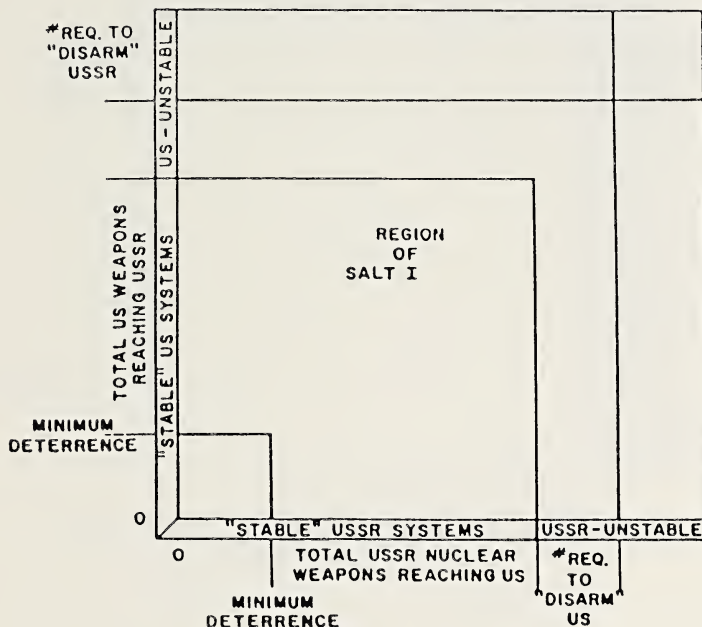


CHART 12

to go one step further. You have to say, all these weapons will always be able to get through to the target. So if you have too many, they can never be taken away, and they can always be delivered, that's perfect logic and you ought to be able to reduce. To complete the logic we agreed not to defend (the ABM Treaty).

Unfortunately, the world didn't stay like that for very long. You first get the SS 18s and you get a few more systems of that type -- and by the way, MX is of that type, too -- and you introduce a new type of weapon, a weapon that is called an unstable weapon. The unstable weapons are those that can take the other guy's weapons away. I don't care if you have a few of them; that doesn't bother me -- it is when you get large numbers of these things that I start to get concerned (Chart 12). And I'm going to call that level, where one side or the other might be able to quote disarm the other -- now by disarm, I don't mean totally disarm. I mean disarm enough that you could stand the punishment coming back, because you never get rid of them all.

So there's only three levels that I'm concerned about. The first is minimum deterrence, which is not very many weapons; the second is a philosophical zone where if you met the three criteria, you'd be able to reduce weapons; and the third

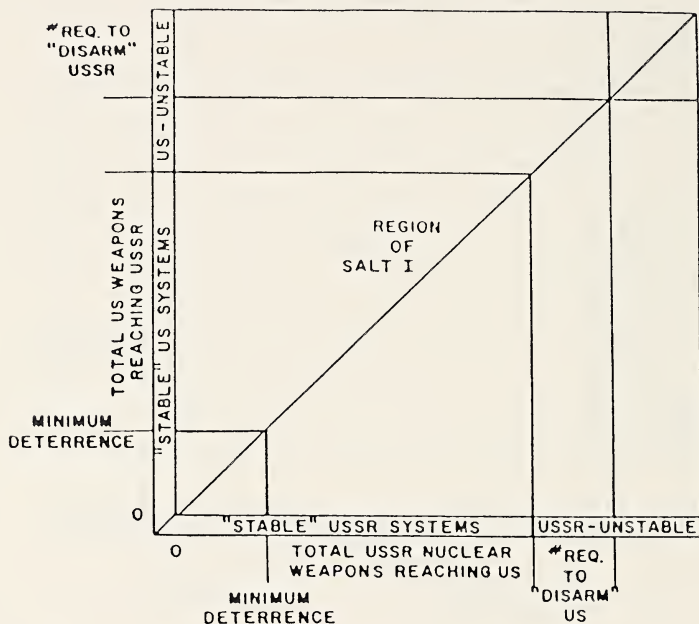


CHART 13

is, wow, out there where one side could really gain an advantage by going first (Chart 13).

There are some zones you've got to say out of. You'd like to be somewhere about the middle, by the way, for this mutual -- you know, roughly balanced. You need to make sure that you're not over here (Chart 14), because if you're over in there, the Soviets could disarm us. Don't like that idea. Because of the word "mutual," you need to avoid this -- I don't want to have a position where I could disarm the Soviets; it's not allowed. Up here -- and by the way, those are crisis unstable, those little wavy lines, because somebody has an incentive to go first -- up in that far right-hand corner, I can disarm him and he can disarm me. In a crisis, the only way to survive is to go first. You've guaranteed yourself a nuclear war, if you find yourself up there.

Some other areas that you want to avoid: I always want to be able to do minimum deterrence on the Soviet Union, so I want to avoid that (Chart 15). The word "mutual" says I've always got to allow them to do that on me too, so I have to avoid that.

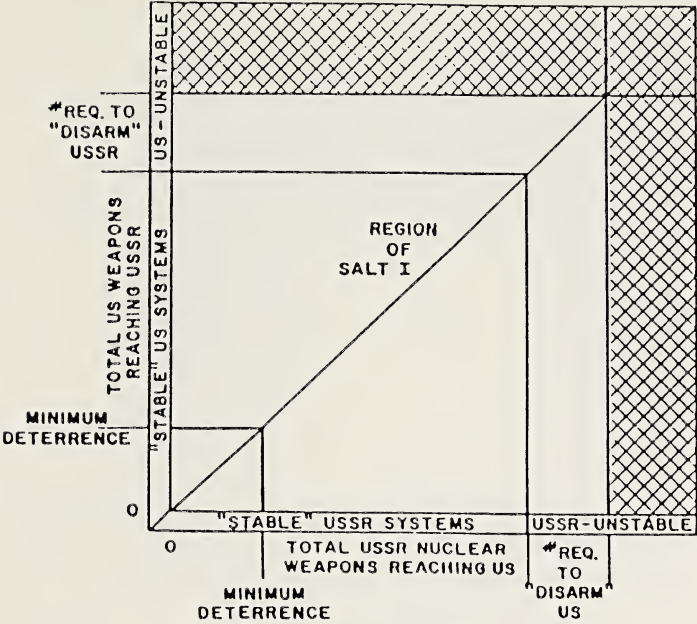


CHART 14

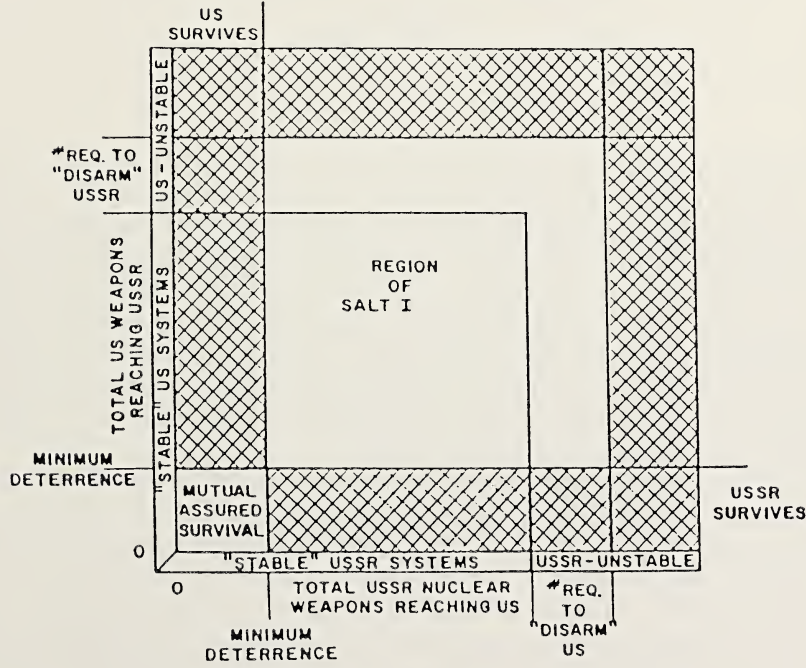


CHART 15



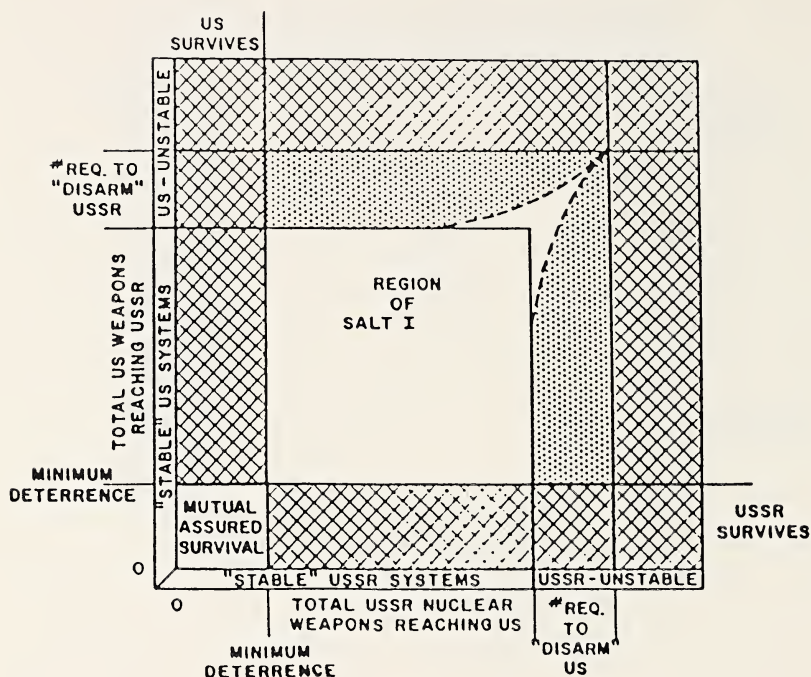


CHART 16

Now there becomes a very interesting region, this lower left-hand box (Chart 15). It's below the minimum deterrence level. If you'll recall the way that I defined that, minimum deterrence, it was that if you were to the right of the line, or above the line, you couldn't survive. If you're to the left of the line or below the line, you can. You might call this area the area of mutual assured survival. You can have a nuclear war down there and live through it -- that's not a very good area. It's doubly destabilizing, as before. Now, I don't know exactly where we are -- probably up in here some where -- but if I want to go from here down to zero zero, I'm going to pass through that area. Now that is a very dangerous area. That bears closer examination before we go trip-trapping in there.

There are some other areas you want to avoid. I know that I want to be on the diagonal, but you know I can get a little bit off the diagonal before anybody cares -- plus you can't measure this stuff that accurately. Let's say, you can get about that far off before anybody cares. Now I've got to play connect the dots. I've got to connect that with that. And the way that I do that is with a curved line (Chart 16) -- I'll show you why in a second -- and I get this far off the diagonal, outside of that line, or that way, something else is going to happen. We're going to "dot" that in. That's arms race unstable. You don't get crisis instability until you get outside the

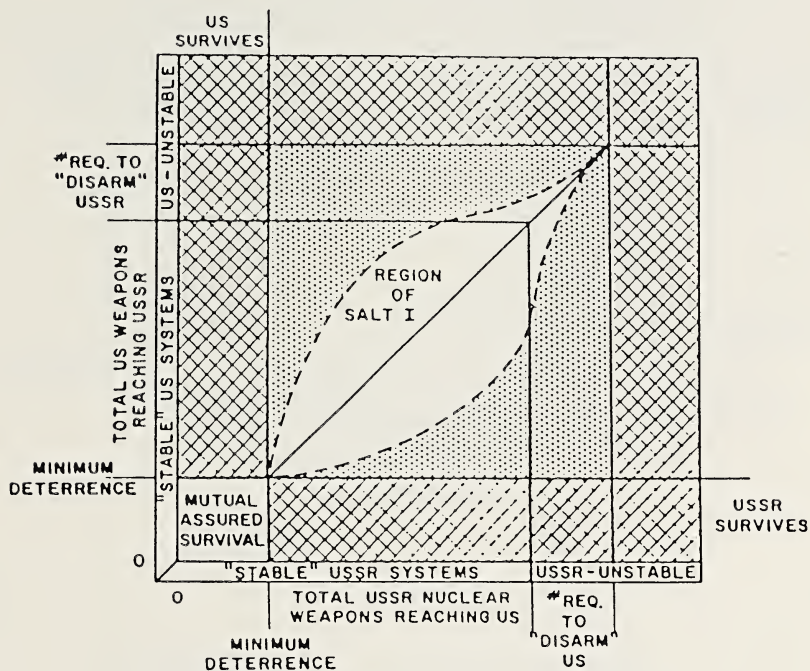


CHART 17

borders; that's the wavy lines.. What it is this thing (dotted area) is so far out of balance somebody's going to kick in the arms race to drive it back into the middle -- perceptions of equality is what you're dealing with.

Well, the line is a curve, but mathematically it's a straight line. However, we're not dealing in math; we're dealing in human perceptions. You're in an area where the weapons are unstable. I can take away your weapons; you can take away mine. I am going to overestimate your capability -- always do; that's my job as a military planner, to worst-case this thing. I'm going to overestimate your capability; you're going to overestimate mine, and as we start to overestimate each other's very terrifying capability, this tolerance for difference is going to squeeze down. More and more of these unstable weapons, it's going to cause me to react sooner and sooner -- sooner than I should, probably, but that's my job, to be safe. So the tolerance for difference squeezes down. You're more likely to have an arms race.

Down in this area, I need to connect the dots again, and I'm going to connect them like that (Chart 17). And again, if you get too far off the diagonal, somebody starts an arms race. But then the shape of this curve's different. You're in a stable

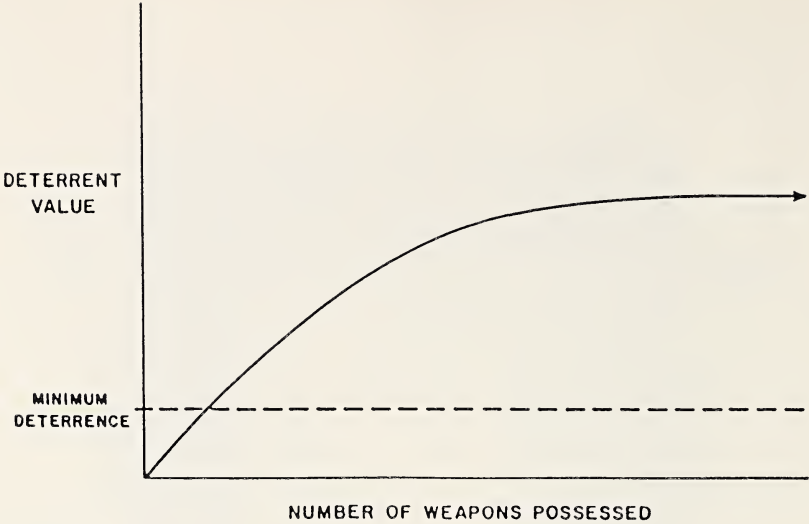


CHART 18

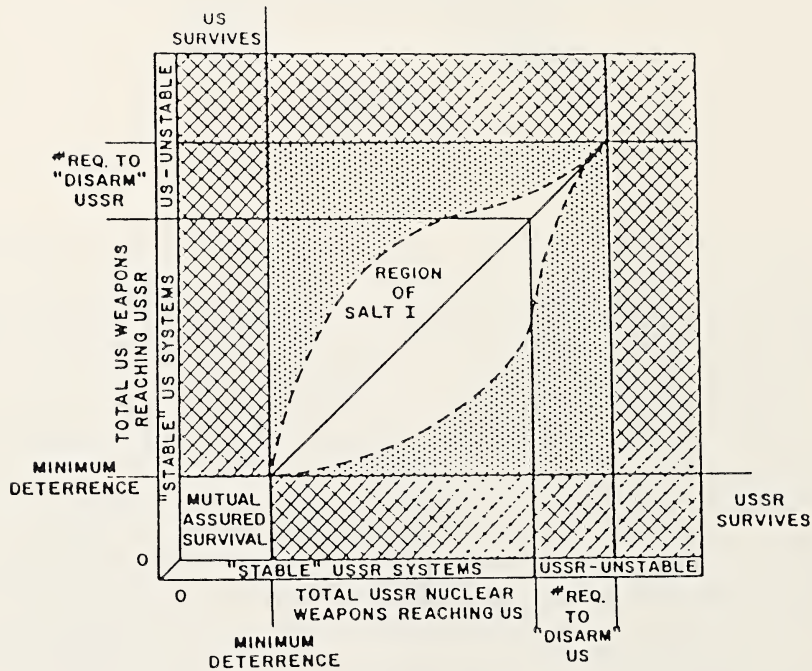


CHART 19



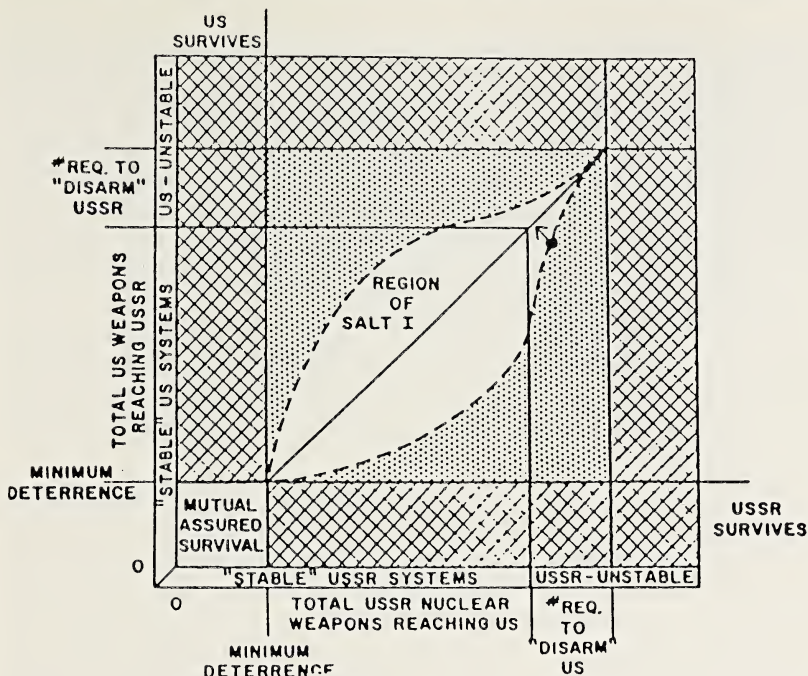


CHART 20

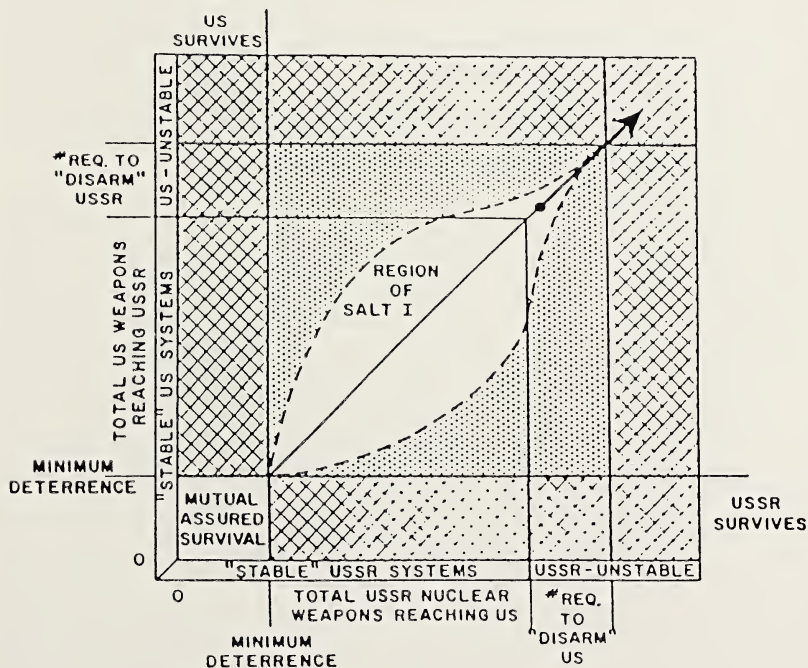


CHART 21

region. Nobody can take your weapons away. Then you're dealing in normal economic return curves. If you've got too many weapons, nobody can take them away, which is the assumption of the SALT I area, then the deterrent value per weapon possessed curve looks like this (Chart 18): you've got a whole lot of them, a difference of a thousand doesn't mean a thing. You get down toward the lower left, where you've only got maybe two thousand weapons, then a difference of a thousand means a hell of a lot. That's what it means, and what that is is that up at the top I've got a wide tolerance for differences; as I squeeze down to the bottom, I really get shaky in a hurry, to where I really care.

Now there's the completed picture (Chart 19). The area in the middle, the clear area, is arms race and crisis stable. That's where I'd like to be. That's my simultaneous solution. You get too far out of that, somebody's going to kick in an arms race to get you back to the middle. You get a whole lot out of there, somebody's going to kick off a war.

Now where are we today? where were we in the eighties? Starting in the eighties, the Reagan administration argued we were right there (Chart 20), and what was needed was the strategic modernization program to drive it back to the middle. I'm not going to defend that or explain it any more, I'm just going to show you where it is, show you how you might work through the model, because I'm not here to explain the modernization program.. Let's assume we're on the diagonal. The sense and direction of movement in the arms race, because of both sides going to prompt counterforce, is upward and to the right (Chart 21). That's where it's heading. We may in fact, if we continue with the offense of the type we are both buying, be in an arms race from which there is no escape. Now, we are not going to get into the upper right hand corner -- it's not going to happen. But the way we're going to stay out of it is an endless proliferation of weapons to make the targeting so complicated that nobody's going to do it -- that's the way you stay out of it. Arms controllers have tried to drive it back down, back down the diagonal has been the direction of arms control, and we haven't been able to make the movement.

Now given all of this, what's SDI? Let's say the U.S. puts in an SDI from where we are today -- again, let's assume balance -- it's a movement to the left, because it reduces the total number of Soviet weapons reaching the United States (Chart 22). That's what it's supposed to do. Little bitty SDI, little bitty arrow; great big SDI, great big arrow. No problem. Simple vector addition. You will note that very quickly it enters an unstable region. Critics are correct. It is potentially destabilizing. But it's arms race destabilizing, not crisis unstable. It has to be a BIG arrow before it's crisis unstable. And there's a difference here. If we want to move from here, and reverse the direction, and get down to there (Chart 23), what the critics seems to forget is that there is another step, and Keith Payne was referring to this earlier. If I want to go from here to here, I can also do it by going two left and two down. You get to the same point. Now, what's the two down? It's to reduce the total number of U.S. weapons reaching the Soviet Union. Now does it make sense, as I add defense, I would reduce offense? It seems to, because if you go back to the chart that says exactly how do I deter (Chart 24), they trade off at the same level on my little paragraph diagram -- if I add this (+), I take away that (-). If I take one sort of insurance, which was buying more offense, and I replace it with another



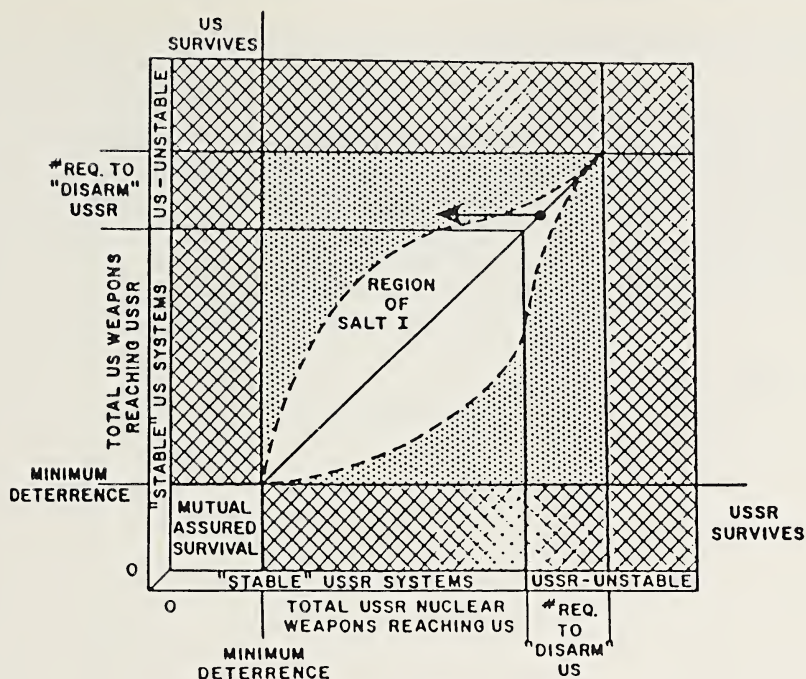


CHART 22

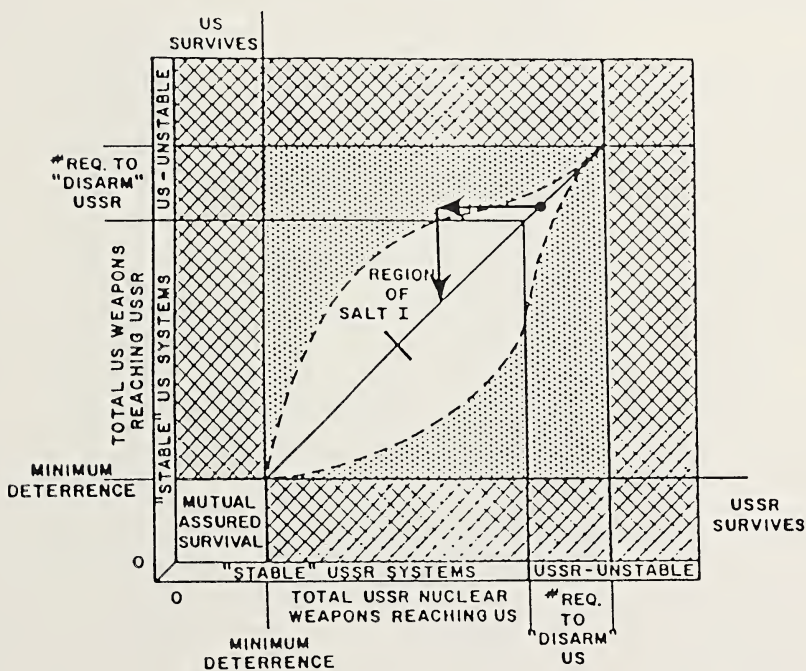


CHART 23



Mechanisms for Deterrence

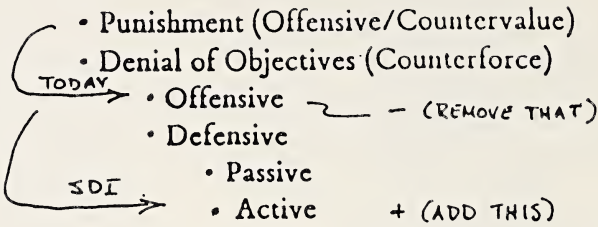


CHART 24

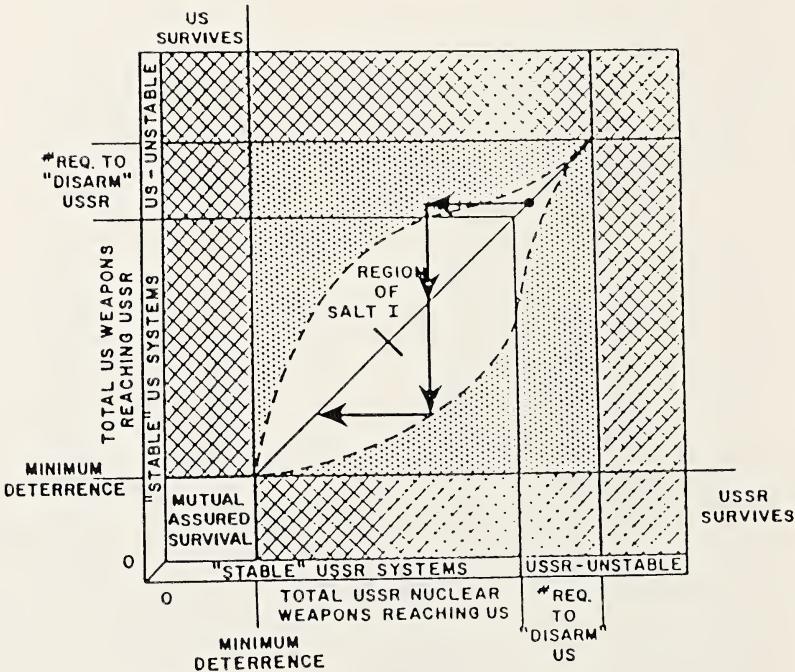


CHART 25

sort of insurance, it makes sense to cancel the policy: so at least it makes reasonable sense to contemplate it.

These are only U.S. actions, by the way; no Soviet vector on here. So I can do this by myself. Now I'm not a fool; I don't think the Soviets are not going to do anything; I'll come to that in a minute. Well, I reverse the direction of the arms race, and I arrive at a region which is wider in this tolerance for difference (clear area). And the tolerance for difference is probably the key to arms control, because we don't have the same force structures and we don't have the same background, so a tolerance for difference may be the key. By myself, with no action by the Soviets, I can reverse the direction and widen the tolerance. Not bad.

But like I say, I'm not a fool, and the Soviets aren't going to stand still and do nothing, so we need to analyze, what could they do? Well, let's suppose the Soviets do the same thing we do -- you might say it's unlikely, but as an analyst you have to consider all the possibilities. Suppose they put in a defense and reduce weapons. Aha! I go further down the diagonal (Chart 25). The critics argue that ourselves and the Soviets can't do it together; I don't think that's correct. I think we can. We can march, by the way, along the same path that arms control wants to walk and hasn't been able to. One little problem, here, though, is once I pass whatever this midpoint is, and I don't really know how to define it, this tolerance for difference starts squeezing back down. So I run into the same problems down here as I did up in the upper right. And also, if I'd truly like to go to zero, I'm going through this area down here (MAS), so I still don't look at that. But it seems that ourselves and the Soviets, doing the same thing, defending, and reducing offense, can walk a path together that makes sense.

Now what if the Soviets don't do that? Sometimes they're uncooperative. What if I put in a defense, and then I reduce, and they build (Chart 26)? That's fairly important, because that's what they say they're going to do. They've got to build more down here than up here (Start) before I care about it. Up at the top, they build a little bit, I care. Down there, they've got to build a lot more before I care about it. But at some point I'm going to have to do something. At that point, I've got two general choices. I can put more defense in and drive it back to the middle -- might be able to do that. The trouble is, you go through two or three rounds of that, where they add more offense and I drive back to the middle with defense, and all of a sudden the defense fails, then I bear all the burden of failure of that defense. In the words of one of our presidential candidates, I'm in deep doo-doo, right?

Or, if I don't want to take the defense and roll it back, I might build (Chart 27). So here's this little cycle, I defend, I reduce; they build, I build -- hey, I just walked in a circle, and I spent a lot of money doing it, and that doesn't make a lot of strategic sense. Well, this is part of Nitzze's criteria that says, you don't want to get into a ball game like this. The only time that you want to start this with an adversary that might try to oppose you by building offense, is when it is absolutely clear that the defense can outpace the offense. Well, this diagram is why. If you get into a determined adversary who is going the other way (offense) and all you have is a defense that is not clearly better, you're going to walk in a circle and you're going to spend a hell of a lot of money -- and that's stupid, so you don't want to do that.

Third possibility is like this: *before* you deploy an SDI, he builds (Chart 28). Now you've got to build, because you don't have a choice (no defense to put in).

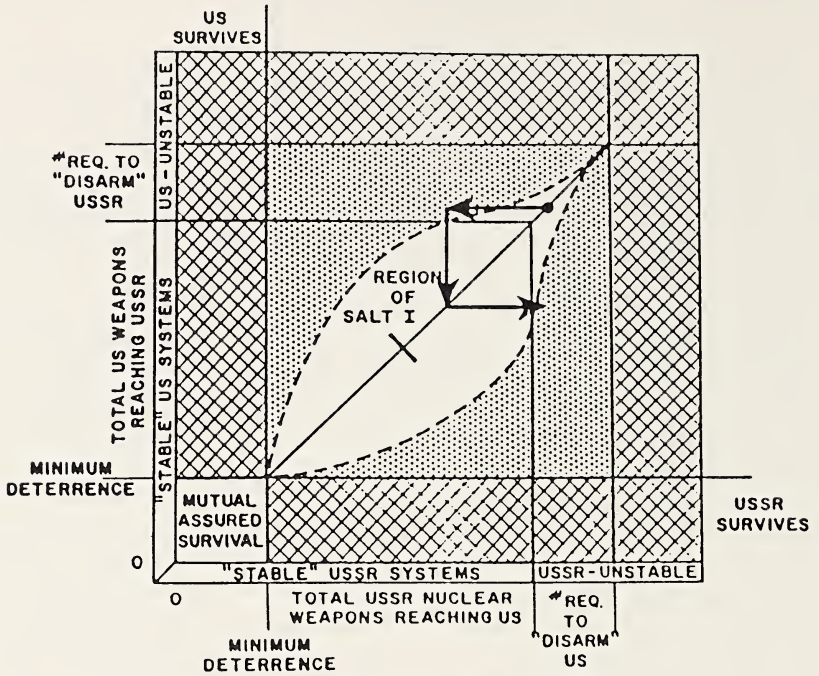
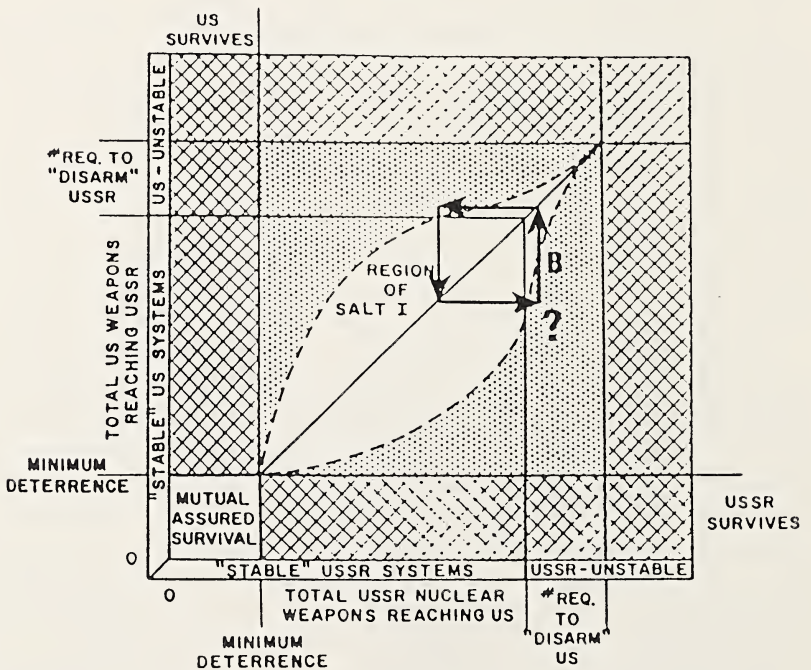


CHART 26





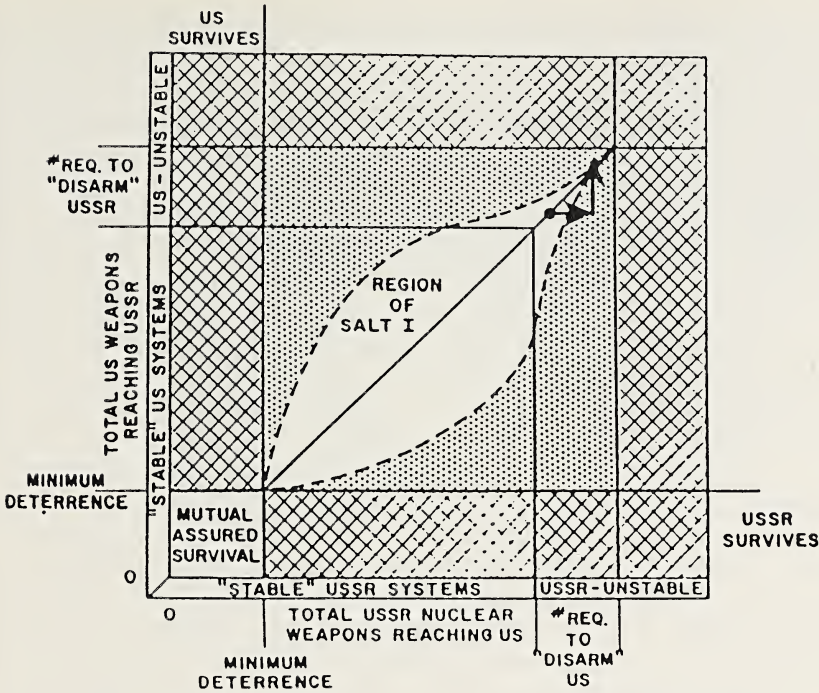


CHART 28

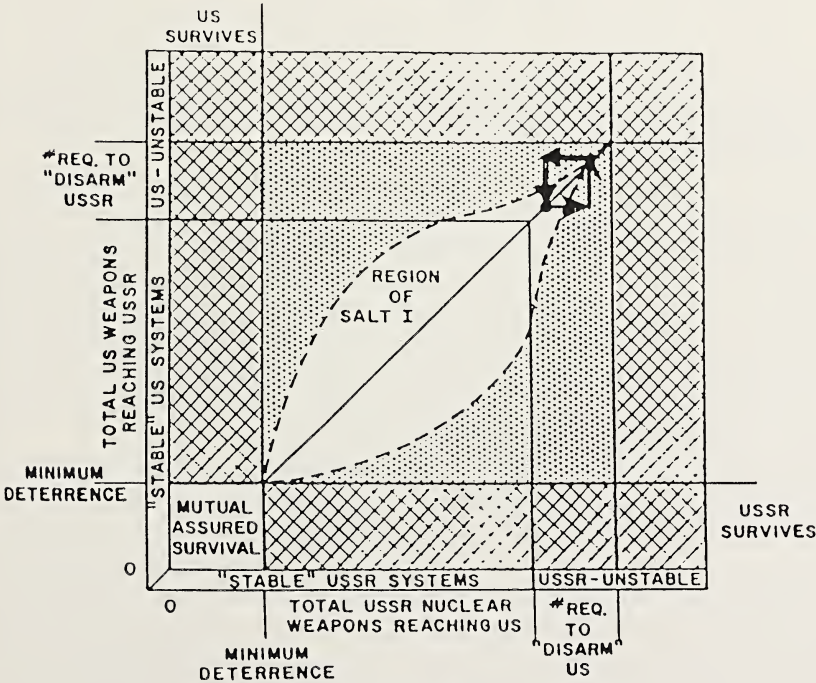


CHART 29

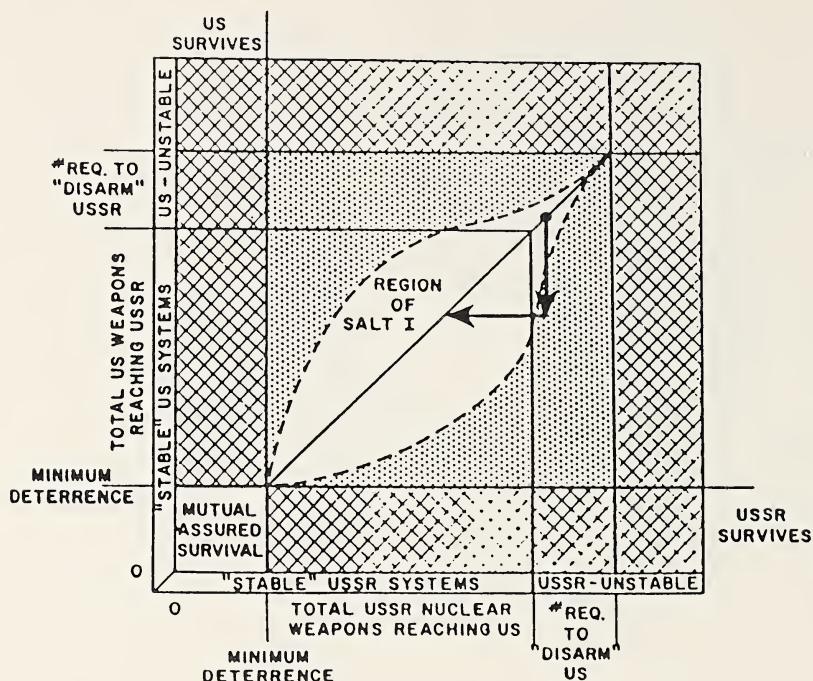


CHART 30

Now later steps would be defend, reduce, also in a circle, but this one is a little bit more dangerous (Chart 29). Now that is not exhaustive on the list of possibilities, but it's reasonable to analyze the field.

And there's a temptation here to say, Well, gee, I've looked at three possibilities, two of them are dumb, therefore, two out of three, I throw the thing away. Well, we can't do that, because these possibilities are ten to fifteen years away as far as determining which way you might go in looking at the technologies; they're in the minds of men and women who are not in power today. An analyst might say, Okay, great, I'll assign probabilities to them and I'll run the little decision tree out. You can't assign probabilities. We don't know what the probabilities are; you can't measure it. Perhaps make them all equally likely; you can't do that either -- they aren't equally likely, we just don't know where they differ.

The point of the analysis is, what you need to do is to figure out a way to block bad moves and gives incentives for good moves. Bad moves are up and to the right; good moves are down and to the left. Is there a way to do this? Yes, there probably is. I said, before, that I would go: reduce, defend. Can't you see that phone call? Mr. Gorbachev, this is Mr. Reagan. You been worried about SDI; I'm going to put it in. But as soon as I'm done, I'm going to reduce offense. Trust me. Phone call wouldn't go the other way, either. Gorbachev expanded, we'd build. Suppose I did it like this: Mr. Gorbachev, we're going to defend ourselves, but I don't want to do it in a manner that threatens you. I'll reduce offense first -- some -- and of the right



type -- and then I'm going to put, in in some proportion, a defense (Chart 30). I'm taking the risk this time, because I'm upsetting the balance to your favor. I make no guarantees that that would work, but at least it doesn't provide the incentive for him going in a different direction. Now would you do that? That's an interesting question. You might do it with little ones. I wouldn't do it with a great big one -- that's dumb -- but with a little bitty one, I might be able to undertake the political risk. And by the way, the technology is only offering right now the small steps. So what I've got here is technology offering me small steps and the political reality demanding small steps. When those two things agree it's almost like having two lawyers agree -- I mean, this is awesome (laughter) -- or two intelligence experts (laughter). So I think I could do that, in small steps.

Does the rest of the path depend on SDI? No, it's the same path as arms control. Maybe SDI is only necessary to turn the vector around. Nothing else has turned it around. And then maybe if you turn it around, you use arms control to lower the threat, the SDI becomes more effective -- but you still have to come to grips with what happens when you go down this diagonal, and this is part of the future vision.

Well, there are at least three things that happen politically when you go down diagonally. And I want to go down the diagonal very quickly here, with and without defense. I want to go down it without defense first, and then I'll do it with defense, on three issues. If I go down the diagonal without defense, one of the things that happens after a while is the number of weapons that the Soviets and U.S. possess is equal the number of the French and the British -- that is granting co-equal military superpower status to another nation. I've got to go back in history and say is there any precedent for that? You've got to be careful looking at history, because one of my math profs down at Georgia Tech said, Be careful, Stephen, you can't really learn anything from history. It's just the same damn thing over and over (laughter). There is no precedent for voluntary granting of co-equal status. Status changes are a part of war or of more gradual processes where one side is determined to overtake the other; it doesn't happen voluntarily.

So let's assume, then, since we're playing walking down a diagonal, that the French and the British and the Chinese and everybody else that's got nuclear weapons decides to come down in some proportion to us. The next thing that happens, as was discussed briefly before, was verification becomes a real problem. Now it isn't verification that becomes the problem, because I can always look and see how many he's got over there -- it's enforcing the verification that becomes the problem. We said, right now I can verify plus or minus five hundred without a great deal of problem. You get down to five hundred, verifying plus or minus five hundred is a big hiccup. The other guy shows up with a thousand -- I verified it -- I verified that he's in charge, that's what I verified. You need a way to dampen that. And to the degree that you don't have defense, you are very sensitive to low numbers of forces. It's a real problem.

The third is proliferation. Right now there is little or no incentive for other states to gain a nuclear weapon. It may be of regional importance, but it doesn't mean anything to the superpowers. You get down there at ten or twenty weapons, a more radical state may see an overwhelming incentive for them to gain the weapons themselves, and I think directly of people like Khaddafi. Now he's another



colonel -- you've got to be careful there (laughter). You don't want Khaddafi with nuclear weapons.

Now on those three issues, let's walk down that with defense. French and British weapons, rather than granting co-equal status late, are negated early. I don't say this as a good deal, I just say it's a different problem. That one may be more manageable within the alliance. On the verification issue, verification disappears to the degree that the defense is robust for the type weapon you're defending against. And on the third issue, proliferation, the incentive to proliferate disappears to the degree the defense is robust. There are other things that happen; those are three political.

There are some military things that happen, too, and I'm just going to show you real quickly, because here it doesn't make any difference about defense. I don't care how you go to eliminate nuclear weapons: by defend-reduce defend- reduce, or just let's get rid of them, throw them into the sea (Chart 31). If you get rid of your strategic nuclear weapons, you'll eliminate those outside blocks, and the only thing that is remaining is steps one and two. You have just made Europe safe for nuclear war, because the two superpowers can conduct a nuclear confrontation on European soil without directly affecting their homelands. That concerns the Europeans, and rightfully so. So let's get rid of nuclear weapons in Europe as well (Chart 32). And now you have made the world safe for conventional war, and P.S., you lose. I don't think that's a noble objective.

Now what that tells me as an analyst is, you don't start unraveling this thing called flexible response or the linkage, until you solve the conventional problem. You start the problem here in the middle, and you solve there, and then you can start working back from the outside -- that's where you solve it politically; you do the R and D, you do the thought process on the outside, but you better militarily solve this problem in the middle (conventional forces). Fortunately, as the General mentioned and others have as well, there are some of the new technologies that are coming along that may allow us to fill the gap in a manner that provides for defense without also providing for offense, which is the same thing Gorbachev is talking about. If I can prevent his arrow from coming my way, while still guaranteeing that my arrow can't go his way, I've broken the code, because then I can do extended deterrence in a non-threatening manner and have a stabilized relationship and go through the rest of the steps.

It is my own personal view, though, that you don't go beyond whatever this midpoint is until you change the basis of the model. The basis of the model is twofold: it is that superpower relationships must be based on fear; and that the method of instilling fear is nuclear weapons. You change any one of those premises, I'm for going beyond the diagonal. Let's consider changing the second one first. Keep fear, but do it with something other than nuclear weapons. That's quite satisfactory to me, but it is not the end objective. I would rather change the relationship from mutual fear to something like mutual comfort, and I can only provide mutual comfort by mutual defense, and I only get to that by introducing and thinking through defense.

Some may think SDI is just another American attempt to use technology to solve what is actually a political problem. I do not think this is the case. Technology will never solve, by itself, political problems. But it is not wrong to ask the scientific

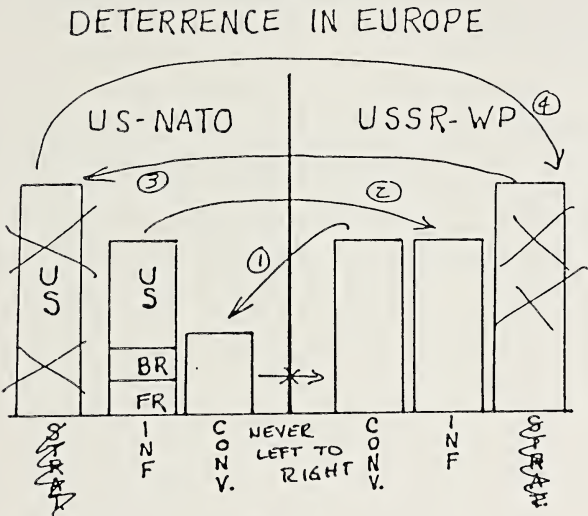


CHART 31

CHART 31

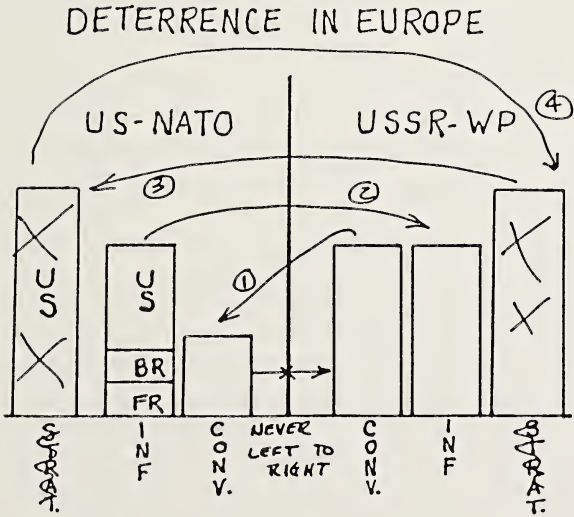


CHART 32

community to provide technology which might help, might be blended with other diplomatic tools. This is what the President requested and this is what the SDI actually is. Thank you very much.

Dr. LALL:

Thank you. My approach to the subject, as you can imagine, is not quite the same as my colleague's, and let me start talking about what it is. I think in the long run it's in the interests of the United States, as well as the Soviet Union, to reach agreement going down as far as we can to lower and lower levels of weapons, depending on whether our relationship can improve, so that we do have some confidence, and can work together. And also, as we reach agreements, that when we need to include other countries, we are able to do so. I also add another objective, that it's not only that we want to reduce weapons, but we really want to make an international global security system work. In order to do that we have to have enough in common so that we involve other countries into a truly global security system. Those are big objectives, but I think that is what we must aim to achieve.

If we embrace the SDI, as a system that we think helps our security and helps us to get to other agreements, then this would cause the United States to nullify two very important agreements, two of the agreements that we have already entered into, and that are in force, and one which we hope to enter into in the near future. And so let me talk about that.

I think, also, conceptually, as we look at the possibilities for strengthening agreements and getting into new ones, we should register that we are at the threshold, perhaps, of a very important dynamic period in our relationship with the Soviet Union. We have a new generation of leaders there, leaders that do want to change the nature of their system, make it more efficient, and want to cooperate because they realize that cooperation is essential if they want to make their whole system work much better than it has in the past.

The Soviets have shifted their position in the United Nations in the area of peacekeeping, and they have opened up, as we've seen, in a remarkable way. And when we see them and talk to them they tell us that they are prepared to go further.

Within that conceptual framework, let us look at these treaties and how they're related to the ABM treaty. First, we concluded a treaty that isn't of tremendous significance, but has a lot of potential, and that is, we concluded an agreement on outer space -- this was back in 1967. That agreement basically says, we don't want to have weapons of mass destruction in outer space. They're gone. We don't want to have nuclear weapons tested in outer space. And that's a commitment. That treaty does not talk about other kinds of weapons, but we do know that some of the weapons that would be part of the SDI would be nuclear weapons; for example, we have the X-ray laser that would, under certain circumstances, be popped up into space, and it's quite conceivable that there are other weapons also that would be involved. So the space treaty not only would be violated by the SDI in the current situation, but we would lose an opportunity to keep weapons out of a whole environment in which space itself is increasingly going to become more and more important to all of us.

Then let us look at the next treaty, the Anti-Ballistic Missile Treaty. This, one can argue, has been the most important and significant treaty that the United States



and the Soviet Union have entered into. For the first time, that treaty said we will not build a ballistic missile defense system; we will not build an SDI, and therefore we have committed ourselves not to enter a whole new area of the arms race. We've taken space out of our competition. The SDI would completely nullify that treaty. We would not be able to say, we are banning ballistic missile defense. SDI, according to the interpretation that President Reagan's legal advisor in the State Department, and others in the administration have given to that treaty, says we can do anything we want to because we have changed the interpretation of the ABM treaty. So another treaty goes by the board that helps to build a world of stability and weapons reductions that I think is the aim that we want to work toward.

Then let us look at the third treaty that we're talking about here. That is the proposed START treaty. We and the Russians have committed ourselves to try to take a bite out of our strategic offensive competition. This has been a long commitment; it was a commitment when we signed and ratified the ABM treaty. We've been negotiating it, started way back in the Nixon administration, when the SALT I treaty was ratified, along with the ABM treaty. But the SALT I treaty expired, and then we negotiated a SALT II treaty, in 1979, and that would have reduced somewhat the level of strategic nuclear weapons. The SALT II treaty would have set forth some guidelines on how we behaved in terms of building future weapons, but SALT II, again, was supposed to have been an interim step to allow us to go further down the road to reducing strategic weapons. But SALT II was never ratified. The Afghan war started. President Carter at the time said we wouldn't try to press this treaty. The Senate probably never would have ratified it anyway, because it had questions about the treaty; it also agreed with the president, basically, that we didn't want to ratify a treaty with the Russians moving with thousands of men into Afghanistan.

So the whole concept of strategic reductions was pushed aside until the Reagan administration finally, after the first few years, decided that it made some sense to try to talk, at least, about a new strategic reduction agreement. They gave it a new name: instead of SALT, they preferred to call it START, Strategic Arms Reduction Treaty. That treaty is not ready for signature at this time. Both sides wanted very much to finish it this year. The Russians understand our political system enough to know that every time there's a new president and an election, we get delayed for months, sometimes years. A new Congress comes in; they all have to learn anew about a new treaty. But there are many aspects of the START treaty that have been agreed, that both sides in a sense have initialled, and that can be preserved, so that a new administration, when it comes to office, would have that as a basis for negotiating the treaty, and it might take several months, maybe longer, but there is every hope that that treaty can come to fruition.

It cannot come to fruition, however, if we go ahead with an SDI system. And the basic reason for this is that if we begin to reduce, drastically, our offensive weapons, then we've got to be sure that there's not going to be a defensive system up there that will be destabilizing. The Soviets fear that if the United States has a system of defense and the Soviets do not, we may contemplate a first strike. That is what either side would be worried about. So what you want to do is have a sense of stability on the defensive side, so you can go ahead and reduce on the offensive side.

The reductions in START are not what a lot of us would like, in terms of making substantial reductions, but the aim is to try to reduce the number of warheads by approximately fifty per cent. They talk about a figure of six thousand -- that assumes that both sides roughly have twelve thousand strategic nuclear warheads; each side would reduce to six thousand. That is not exactly what's going to happen, because the way they have counting rules for the various kinds of weapons, it's more likely that the two sides would end up with nine thousand. So we may get not a fifty per cent reduction in strategic warheads but, instead, maybe a third, maybe twenty-five per cent. Still, it's important; in fact, it would be the first really deep cut in our strategic systems.

We also, in this Start agreement, would try to reduce the number of the delivery vehicles -- the submarines, the long-range bombers, and the intercontinental ballistic missiles, to a level of sixteen hundred. Both the U.S. and U.S.S.R. now have at least several hundred over that now.

There are other levels which the two sides would try to reach. They have agreed that with respect to the intercontinental ballistic missile warheads on land and also those on submarines, they would be reduced to four thousand nine hundred warheads. Again, very high.

The U.S. and U.S.S.R. have agreed to have a reduction in the throw weight of missiles, and this is something the United States particularly wanted to have. Soviet missiles are much heavier than ours and we have wanted to see that weight reduced.

There are counting rules for the air launched cruise missiles. There are counting rules on bombers. Bombers contain nuclear gravity bombs and short range attack missiles with nuclear warheads. No matter how many gravity bombs or short range attack missiles are on a bomber, they all count as one on a bomber.

These are the basic reductions in the START agreement. Again, they do not sound like a lot, but they go farther down than we've ever gone, and they open up a regime to go beyond that.

Verification will be based on the recent INF treaty that the U.S. Senate ratified last June. The INF treaty, intermediate nuclear force treaty, takes to zero two whole classes of nuclear weapons -- that's the first time we are destroying nuclear weapons. When I say nuclear weapons, one has to explain what that term means. In this case, the nuclear weapons mean the missiles and the launchers. It does not mean the warheads. The warheads are not destroyed; they've been taken out of the missile; they will be reused in terms of the fissile material in them. Many people -- and I am one -- would argue that, on the START treaty, the number of warheads, once they're taken out, whether it's six thousand or nine thousand, ought to be reprocessed, and not used again as nuclear weapons. Thus we not only would get a reduction in the delivery vehicles, the missiles and the bombers, but we also get a reduction in the warheads. Many people say, "but that's very expensive and it's very difficult, and where are you going to bury this stuff?" But we have invented this monster, and we need to begin to find a way to get rid of it, rather than to say it's impossible and we're going to have to have it around forever.

The verification system would be based on the intermediate range nuclear force treaty of the United States and the Soviet Union.

For the first time the Soviet Union opened itself up to five different kinds of on-site inspection. First, the Soviets decided that they would give us an inventory, a



baseline, if you will, of all their missiles and where they are, and we did the same. Both sides have a right to go to every single one of those places and take a look to see if the baseline, the inventory that was given, is accurate. And in the Soviet Union this amounts to seventy-seven different places, plus five in eastern Europe and for the United States it's twenty-two different places plus five of our allies in western Europe. So all of those places are subject to check.

In addition, the missiles in all of those bases must be taken out and eliminated, destroyed, whether they're burned or crushed or exploded. Some of them are even allowed to be put static display so you will know what a certain kind of missile looked like -- the University of Virginia could maybe apply for one of those fifteen missiles if you like. The United States and the Soviet Union, as part of the verification system, will together observe that those missiles are being destroyed. We will bring ours all back to the United States; the Soviets are destroying theirs also in the Soviet Union. We are watching that together.

Thirdly, both sides, when a base is being closed that had missiles, both sides must together inspect that base to be sure that everything is closed out, and that's why they're called a close-out inspection. This is the third kind of on-site inspection included in that treaty.

A fourth inspection is one that allows both sides to monitor one production plant. There was, on our side, some suspicion that the Soviets might try to produce one of the missiles banned, the SS 20. There was another plant right next to the SS 20 plant, producing another missile. So for thirteen years each side gets to put somebody at the portals of each of those plants. In the United States, we're taking a plant that's already closed, the Pershing Two Missile plant at Magna, Utah, where there will be continuous monitoring by the Soviets.

And finally, both sides will have on-site short notice inspections, a hundred and eighty five of them over a thirteen year period, where with only an hour's notice, we can say we're going to go and take a look. The experience of the INF Treaty that we've signed and is now being implemented within three years, will be reflected in the new START treaty.

There's one other verification issue that I would like to mention that is still not agreed. The United States wants to go beyond any base that's already mentioned as being involved in the reductions, to say, in a sense, "We suspect there's a site that we want to look at; we want to go to some of the sites anywhere, any time, any place." The Soviets are rejecting that kind of rather broad permissiveness on inspection, and so the two sides will probably find some compromise in coming to agreement on that kind of inspection.

The START agreement, therefore, will have all of these INF on-site inspections plus some kind of suspect-site inspection. But we will not reach an agreement if we continue to insist that the SDI must go forward. The Soviets want a kind of stability, and I would think that we would want it too, saying that, all right, we are levelling off on the whole question of defense, and therefore we can move to reduce the offense. It is this relationship that makes START so important, and makes it so important that we do not continue to insist that we pursue the SDI. We are talking also about how we might find some accommodation on the SDI. We've talked about a ten year commitment to observe the ABM treaty, and from then on anything goes -- we cannot go ahead with these agreements if we are not willing to find



some way to stabilize the arms competition. That is one reason why the whole program for START is held up because of the SDI.

Now let me also mention another area that I think is very important with respect to our continuing these agreements, and where the position of the U.S. at the moment is unfortunate. That is the area of using space for verification purposes. I've mentioned that we have a space treaty. We're had no verification in space to look at satellites or anything else in space, but increasingly we are putting up many things in space; we have not ever said that you can't put any weapons in space. We've only said that you cannot put nuclear weapons in space, you cannot test them, and you cannot put weapons of mass destruction up there. But a lot of the SDI weapons are not necessarily weapons of mass destruction, and there are plans, all kinds of plans, that conceivably could put other weapons in space, and, again, continue the arms race.

There is a proposal at the United Nations, now supported by the Soviet Union, the French, the Swedish government, the Indians, and several others, to begin to deploy an international verification satellite and an international verification agency. If we reach some agreements that are just between the United States and the Soviet Union -- when we use our own national technical means to verify them, that's sufficient for a bilateral agreement. But beyond that, if we expand the commitments about not testing or not deploying weapons of any kind in space, if we have a comprehensive test ban agreement, in which many countries joined; and if we had other agreements, for example, in conventional arms area in Europe, where we are now about to enter negotiations, we can not have then a simple bilateral verification agency. We then have reached a point that we need an international approach to this question of verification. We should try to persuade members of Congress and our government that the U.S. ought to begin studying what kind of an international verification satellite, international verification regime, we want to create to verify these multilateral treaties.

In conclusion, I submit to you that we are throwing out the window, so to speak, three important treaties, two of them in force, the ABM Treaty and the Space Treaty and throwing out a very important treaty to start reducing offensive strategic weapons, the START treaty -- if we insist on going ahead with the SDI agreement. I think if we look at the choices and also the other kinds of agreements that we need to begin to negotiate, such as a comprehensive test ban, then the choice ought to be, let us put the SDI aside, go ahead with the Start reductions, take advantage that we have opportunities for other kinds of agreements with the Soviet Union, if this glasnost and perestroika holds out. We've got to hope, and work with the Soviets to see that it does. Thank you very much.

Mr. NOWLEN: Please identify yourself when you rise to ask a question.

QUESTION: I'm Admiral Gayler, and I want only to say that the doctrine that military planners must always overstate is very dangerous. I speak as an ex-intelligence official. The job is to say it the way it is, not to understate it or to overstate it.

Col. FOUGHT: May I respond to that? Well, first of all, Obie O'Brien says hello, admiral. That was Admiral Gayler's exec when he was at SAC, who happens to be a close personal friend of mine. At any rate, when I said "must over- state" I think that's just a thing that happens, admiral, and I think you see it all the time, is that the military technical analysis, as you well know, has to look at capabilities. Worst-case is a part of that, but obviously has to get tempered with judgment. The phenomenon of those two curves going in was the simple observation that that's what tends to happen, and it gets worse as that type of weapon continues to -- as you get more and more of them. No, the

military technical analysis should strive to go to exactly what the curve is, but as we know, that is not what happens, and in fact it's not something that's particular to the U.S.; it's happened on both sides.

QUESTION: It has a very dangerous effect; if the intelligence community is under pressure to call the intelligence the way policy wants it to be rather than the way it is, and I'll just close with that observation. It is getting late.

QUESTION: I have a question for Col. Fought. On one of your early charts, the one where you show the various types of weapons and conventional forces, if I understood correctly you said that the purpose of the nuclear weapon is to prevent a conflict with conventional forces, and that the Soviets had a very much superior force to the NATO allies. Perhaps I misunderstood you, but if it is true that the nuclear forces are simply to prevent a conventional forces conflict, why have any, since the Soviets are already vastly superior, why have any conventional forces in the NATO --?

Col. FOUGHT: That's a great point, and no, you didn't mistake my point at all. Let me show you the chart here. This is not controversial left or right; this is a concept that is referred to as the nuclear threshold. There is a credible argument -- it's typically a European argument, by the way -- that you ought to have about that many conventional forces, just enough to let them know you're there, so you can tell the other side's coming, and then wham wham wham wham -- that's a tripwire strategy, something that more or less happened in the fifties. The U.S. spent a lot of time with NATO between 1961 and 1967 to say we need to push this nuclear threat -- more conventional forces to handle something other than ambiguous aggression -- this was Kennedy -- saying if the Soviets are chasing the East Germans across the interGerman border, and I'm not sure it's the real thing, I'm not going to end the world. I want flexibility in nuclear weapons and I want enough conventional forces to make sure that this is unambiguous aggression. The Europeans said, you know, weak conventional forces are the key to deterrence; the key to deterrence is that it goes one, two, three, four as fast as you can. That deters. We say, not so fast, squid-breath, we want some time to make this decision because it's our life. And we have pushed for more, they have pushed for less. The real argument, if you want to get down to nuts and bolts, is dollars. Conventional forces cost a lot of money. We could go back to a trip wire, but most specialists say that's not credible. You see the movie "Blazing Saddles"? You remember when the black sheriff took himself prisoner and put his gun to his head and said Don't get near



him -- he'll do it! That's a blazing saddles approach to deterrence (laughter), and it's not credible. Now one of the ways that -- if we went to that sort of a force, weaker conventional forces, you might get a European nuclear force, for fundamental deterrence. Now I've got a problem with that, as a U.S. citizen, and I'm going to say that on the way to sitting down, and it is that if we violate the NPT, which would be what would happen then, it's not going to be the Dutch that get the weapons -- it's going to be the Germans. I don't like that.

Dr. LALL: May I just say something? I think the inference that if you're going to reduce conventional weapons in a balanced way in Europe, therefore, it means you've got to have more nuclear weapons --

Col. FOUGHT: Oh, no, no no --

Dr. LALL: Well, that's the inference that I get, that you're going to make up for conventional weapons reductions by having more nuclear weapons --

Col. FOUGHT: I was just talking about making the imbalance greater. No, if you can get that balance solved, you don't need as many nuclear weapons. We shouldn't draw that conclusion --

Dr. LALL: You want to make it clear -- You're saying we should not enter into negotiations with the possible agreement to reduce in a balanced way conventional weapons, because --

Col. FOUGHT: No, I wholeheartedly support CST, conventional stability talks.

QUESTION: Dr. Lall, you are ready to go the Soviet Union for on-site inspection; won't you be concerned about your life as an American person -- the Soviets are common criminals, you know; they kill the Americans all over Europe, behind Iron Curtain, official visits. I would like to know what are your opinions and what would be your safety devices to protect Americans. You said in your closing statement, the other kind of agreement possible with the Russians may be in the future, and I hope it is not, a lend-lease or a Marshall plan for them. I am curious in your opinion, for anything we give to them will we ask -- what you will give in return?

Dr. LALL: Let me make very clear, I never advocated any agreement in which the obligations to do something would be only on the United States or our allies, and not the Soviet Union. That is not what I call an agreement at all. You have to have an agreement in which the obligations are comparable. They don't have to be necessarily absolutely equal, because in the INF treaty, that I talked about earlier, we established the principle of asymmetrical cuts, because the Soviet Union is having to destroy sometimes three times as many missiles as we are, in that treaty, and they're having to destroy approximately twice as many warheads as we have. So it's important, where they have more weapons, that we establish the principle that therefore they have to get rid of more weapons and destroy them. And we did



that in that treaty and that is exactly what also will happen if we get a START treaty.

Now, I am not afraid of the inspection of these agreements. In the teams that now are working in the Soviet Union and the United States, you have on both sides up to two hundred persons; each side has to clear the persons to be sure they're satisfied with them. They all go together on teams; there are groups. I think the way it has started to work, and we've been on it now since July 1, and the general in charge of the on-site inspection agency in Washington has given a briefing, saying that so far, everything is going just the way it ought to go. That doesn't mean there won't be problems in the future. I think when we reach agreements that we know are equitable, or each side believes for its own purposes are equitable, and we have determined the verification, I do not fear that we as Americans should not be willing to participate if we are qualified to do so.

QUESTION: This question is directed toward Dr. Lall. Ma'am, how would verification take into account rail- and road-mobilized ICBMs? After all, these are weapons that are completely undetectable by our present means -- how would we know that there aren't, say, a thousand of these missiles roaming the highways in the Soviet Union?

Dr. LALL: One of the areas that's still in dispute in these START negotiations is precisely the question that you raised. The United States has wanted to ban mobile missiles; the Soviet Union has two kinds of mobile missiles; we at the moment do not have any. That is still in dispute, and the question is, if we do decide to go ahead and ban mobile missiles, and the Soviets agree, then we have to work out additional verification arrangements to satisfy ourselves where they are. I might add, also, that part of this START agreement picks up something that's in the INF agreement on verification, and that is, if necessary, the Soviet Union, for example -- and this is being done in the INF treaty -- has to remove the roofs of things, maybe actually has to display these mobile missiles, so that our satellites can look down and check to see that what is there is what has been said to be there.

QUESTION: I wonder if both of you could respond to the main thrust of the other's argument: on the one hand, that advocacy of an SDI preceded by reduction is stabilizing and potentially welcomed by the Soviet Union; and conversely, that breaking these treaties simply isn't worth the price.

Dr. LALL: You want to go first?

Col. FOUGHT: You ready? Go ahead.

Dr. LALL: I think that we don't want to tear down what we have just spent almost twenty years building up, toward a stable regime of controlling and reducing weapons with the Soviet Union. And that is what we would be doing if we felt that the SDI -- which by the way, is far from certain that it will work, far from certain that it won't bankrupt us, so it's an original pig-in-a-poke situation, that we would be giving up some very specific things that are working, that are in our security in-

terest, for something that is highly dubious in terms of its effectiveness, and probably could bankrupt us as well. Our own studies of the cost of the deployment and maintenance of the kind of an SDI system runs, something in the order of one trillion dollars. That's a thousand billion dollars, with another minimum fifty billion dollars a year to maintain it in its orbits in space and so on. We are talking about something that is very expensive, as well as not very reliable.

Col. FOUGHT: I'll respond now. I made some notes. Let me take this in order. Starting in the beginning, the general approach to world government or a call for world enforcement, universal enforcement of certain superpower arms control or multilateral treaties involving other powers is premature, at its best, and Utopian at worst, with the latter being my more accurate conclusion. Some of the assumptions on violations, such as that we would violate the outer space treaty, assume that the decision has already been made on the X-ray laser, which it has not. The assumptions or conclusions on cost are interesting, but should be recognized as highly speculative, because once again it is research, and since I'm not in the program I can call it research and development, since it's advanced research, to make these determinations. We can't answer them yet. Now the General can't come up and say this is a hundred billion, and Dr. Lall can't say it's a hundred trillion. We don't know. And that's the truth. And we're not going to know for about another ten or fifteen years. I think we can safely say that it's going to be fairly expensive (laughter) -- but then again, it depends on whether you want a big one or a little one, and ground-based ones, I think we can pretty well concede, are cheap. If that's what we want to go with, because we already know how to do it.

The arguments that were presented by Dr. Lall on SALT I, SALT II and on START, which I thought were excellent, by the way, on the complexity, in particular, of SALT II, and the rather curious counting rules associated with START, I think rather than making the point that we shouldn't go with SDI do the exact opposite: they argue the point that arms control, at least as we understand it so far, has accomplished nowhere near its expectations, and in particular START. In other words, I think the case that is made quite well by Dr. Lall, on the failure of arms control to this point, actually makes the case for SDI that we need to complete the logical loop, that we need to entertain, in one package, offensive modernization, negotiations, and strategic defense, and that not any one of them, by itself, is a panacea. SDI should not be thought of without arms control, but arms control should not be thought of without modernization and SDI as well. I think Dr. Lall and I, if we could sit here and think of this thing in terms of all three elements, we can have a reasonable discussion. But if we sit here and say, SDI is the answer to everything, or arms control is the answer to everything, we will do no service and we will arrive at no useful conclusions.

Mr. NOWLEN: Dr. Lall, any response?

Dr. LALL: I'll give one response: one thing I'd like to add here is that on the cost factor, and of course until the whole system is designed, we're not going to know the cost, but we did look at the kinds of components of an SDI system that



are being talked about by the SDIO office. We used the formula that if you take the cost of testing a weapon system, of its early engineering designs, of the procurement, the engineering stage, all of the phases, and you can look at other weapons systems and know approximately what percentage of the total cost each of those stages represents -- what we did was to take other weapons systems, take the percentage, and apply that to the SDI costs, and that is how we got the conclusion we reached. We didn't simply pick this thing up out of the air; we used several weapons systems as our basic comparison in terms of how much the procurement stage costs, how much the research and development stage costs, how much the engineering stage costs, and so forth. And no one has said that this is way off. It's quiet at the moment in terms of what the government thinks this system might really cost in the future.

Mr. NOWLEN: Professor Fought, among your options are reducing the offense, or defending more strongly.

Col. FOUGHT: Relative to Dr. Lall? No, I actually think Dr. Lall and I, if we were not kind of in a debate or trying to stimulate some other conversations, could probably come to some reasonable agreements. I think reasonable people will say, if you've got three options on the table, you ought to examine all three options, and as technology emerges you ought to consider integrating it into your politics, but technology is not a panacea; neither is politics. If we do the technical examination, the political examination, on the SDI, and it doesn't fit the political needs, well, don't do it.

QUESTION: Reed Johnson, University of Virginia. I'd like to ask a question of Col. Fought. I am afraid I'm going to have to refer to one of your charts --

Col. FOUGHT: Oh, God! (laughter)

QUESTION: If you were on a position on your diagonal line and you moved to the left by adding strategic defense, and you moved to the left a certain amount, is there not the possibility that the Soviets might misinterpret the effectiveness, as you and the Admiral were talking about, and overestimate how effective your SDI system is and throw their estimate over into your margin of instability? Is not this danger more severe as you go further down toward minimum deterrence.

Col. FOUGHT: Yes -- the direct answer to your question is, Yes. And that there is -- the bigger the SDI the bigger the chance for that kind of a misperception. Now that to me, as an analyst, not a member of SDIO, but just a person who's analyzed this thing, says smaller seems to be better because it's better understood and better measured, and that probably that's the best way -- if that's the major concern, this misperception argument, and it may well be -- that the best way to increase the effectiveness of defense is to lower the threat, but you still must have the defense to operate with it. I make my strongest arguments for a modest defense, not because it's weak -- I don't sit here and say I like inaccurate nuclear weapons and weak defense; that's dumb. But I just like it because of the other factors: that



it would smaller, easier to measure, easier to understand, easier to operate the proportionality equation. That's gut feel, but you're absolutely correct.

Dr. LALL: Let me just say one point here: there have been other cost estimates made of SDI; one of them, for example, Barry Blechman, who's with colleagues at Brookings, made one, not quite at a trillion dollars, but quite close to that. And I would also add, I'm certainly not arguing, and I don't think anyone who spoke here today has argued that the United States should not continue a research program. That certainly is permitted under the ABM treaty, it has been going on, and we should do that. Part of that research program ought to look more closely than the SDIO office has done so far at cost figures. After all, since that is the responsibility of the SDIO, I think it ought to look at some of these figures and estimates, so that the Congress has a better idea of what the true cost may be, if you don't accept some of the estimates that we have, and others have calculated.

Dr. LALL: But you have not made a full attempt to take all of the different stages and calculate what that might amount to in the end.

QUESTION: My name is Louise Fernbach -- I wanted to ask what you think of Gorbachev's allegation that we could use SDI or the equipment for SDI to militarize space, and it would therefore be quite a threat to the Russians and that he thought it was quite a mistake to militarize space. I ask this of --

Col. FOUGHT: Me? I think we ought to give Dr. Lall a chance to respond too. You want some water? to throw at me? no, I'm undefended here. (laughter) We could run down the argument and take kind of a hard right wing: space is already militarized, ballistic missiles already fly through, there's reconnaissance satellites and ASAT capability. That's kind of an interesting argument for a debate, but it doesn't advance the cause of analyzing what Gorbachev's trying to say. Militarizing outer space: to me, to defend something, is not a mistake, but to use it as offense, that causes me some concern. So the operative question to me, then, is can I use the weapons that would be based in space to attack something on the ground that Mr. Gorbachev has, before he has launched it at me? That would be the rules I'd put on it. And I'm a mathematician, I'm not a physicist, but it just seems to me that the technologies are so far from being able to do that, that -- the technology's here right now; we've got to move it to here to be defensive, we've got to move it to there for offense. I think it'll move; I don't think there's anything blocking it from doing it, but it's a long way. We can move it to here to be defense, to change the general relationship from what I referred to as this mutual fear to mutual comfort, then maybe there will be less of an incentive to move it the rest of the way. So that part of what he's saying concerns me. But you change the basic relationship: there's no way to block the physics -- you can't tell physicists not work on it, you can't tell people not to think about it, you can't legislate behavior, it ain't going to happen.

Dr. LALL: But -- I understood that your question might have referred to the Krasnoyarsk radar? Was that what your question referred to?

QUESTION: -- not specifically, but that some of the things that we would put up into space allegedly for the SDI could be, in a sense, used to militarize space -- not just to hurt their weapons on the ground, but to hurt Russian people, possibly. Just the idea of having things circulating above our heads that would be dangerous.

Dr. LALL: I think that the question of the outer space treaty in the whole thrust of all this, not to militarize space, which is what would be done if you had SDI there.

QUESTION: Roger Schoonover from The Security Group here in Charlottesville. Sort of a general theme keeps running through each of the sessions here has been stability, it's constantly used. I'm wondering though, do you think though that both the imposition of SDI or even the development of SDI and/or the reduction of total warheads, missiles, the nuclear capability, is in itself destabilizing -- ?

Col. FOUGHT: -- is reduction destabilizing?

QUESTION: For example on your chart, the difference between your center diagonal and an area of destabilization is much smaller, when you have a larger number of missiles. Plus as we get down below, we're not dealing with people on this planet -- I just want to get your reaction on it.

Col. FOUGHT: Well, you've got a very subtle point on that model of mine, and I think at this point what we have to do is say, Steve drew a two-dimensional picture of a multidimensional world, and only captured a few of the variables, so let's take ourselves away from the model a minute, to answer a complex question. The general thrust of your question is, do significant reductions upset stability. I don't think so, if done properly. In other words, reductions and instability -- there's not a cause and effect relationship. I am firmly convinced that the world can be as stable later as it is now with fifty per cent of the nuclear weapons. That's the military planners and the politicians' job to figure out what kind of weapons they need to make it stable. There's no cause and effect relationship.

QUESTION: What if it's down to ten per cent, though?

Col. FOUGHT: I don't know. I don't know where the line is. It's a lot lower than fifty per cent before it starts getting really ratty. The worst case is a low number of prompt counterforce weapons that are all vulnerable. That's the worst case, where it is calculable that you can do a first strike and it's not terribly complex to lay the strike down -- that's the worst case. But you don't automatically reach that case, so I don't see reductions as being in a cause and effect relationship with instability. It's something you've got to look at, though; it's a good subtle question.

QUESTION: (Dr. Panofsky) One can make one remark about all kinds of uses of SDI technologies and that will of course depend on which technology you are talking about, but there have been many analyses made both open and not open



which indicate, yes, indeed, SDI technologies, including the ones which were listed this morning, some of them do have major offensive uses, in particular that it would be easier to target satellites than it is to target ICBMs, simply because one's in particular orbits and the other one's not. So therefore you endanger the security of space assets before you ever have a major potential against ICBMs; that is certainly simply a fact. In addition to that, it is also possible not in a direct major counterforce hence to attack the other side's ground-based silos from space, but lesser objectives you certainly can attack with space-based technologies.

Now I'd like to ask one question of Col. Fought on the diagrams. I agreed very much with your presentation and your diagrams. The problem is, of course, that your diagrams have no numbers on them, and therefore different people may have different judgment as to where we are on your charts. And you pointed out that the Reagan administration says we are on the thin little neck up there, and therefore we've got to do something, we're in trouble. I thoroughly disagree with that. I think we are in the very fat part of your graphs where very substantial excursions in the capabilities of either side can take place without any major consequences, and in fact there are many studies, one of which I participated in, which document that fact. That brings us to the other point which has to do with Admiral Gayler's question of worst-case analogies: the problem with looking at the stability/instability situation on these charts, and at the same time saying that mutuality is a requirement of deterrence when you made your list of points here, you have to assume that both sides have the same opinion as to where we are on the chart, and if you have the very extreme view, with which I personally disagree, that we are on the thin neck and that therefore something has to be done, while others have a different view, then how can you expect that the Soviets have the same opinion as to where we are on the chart as Americans have?

Col. FOUGHT: I agree, Dr. Panofsky, with your criticism on it; in fact, let me go just a little further -- not only it has no numbers on it, it is shown as perfectly symmetric, and if I know anything, the world is not symmetric; that's kind of the point of your second argument. I'm a pilot; I am an engineer; I'm kind of a simple person, and what I wanted to do was take a physics-lab approach to this -- only high-school physics lab -- and that was weightless strings and frictionless pulleys (laughter). And if I understand the problem with weightless strings and frictionless pulleys, and I understand what the key variables are and kind of how they work, then when I get out in the real world to work the problem I know how the variables interact, and now I can deal with the friction. That's that approach. I know what variables have to be traded off and I know what variables don't matter, and I know the right questions to ask. As I said with the gentleman over here, when you get down to real live nuts and bolts and compare them, you're going to throw the model away. I completely agree.

Now, can the U.S. and Soviets ever agree on stability? I don't know. We did some other research on this, which takes a long time to explain, but it was written up in the *Naval War College Review* about a year ago, and I sent a copy down to Reed Johnson to play with, but it's a game where you don't have to agree on definitions or objectives, but you can still reduce, and it's done very similar to "Divorce Court" -- you know, you value your weapons, I value mine; it's an old Pugwash ap-



proach. You put ten thousand points on yours, I'll put ten thousand points on mine; I cut a thousand from you, you cut a thousand from me. Nobody has to agree on definitions, we're both happy at the end. It can be done, without agreement on stability or definitions or positions, so we know that that is true. But your critique of the model itself is absolutely correct: it's weightless strings, frictionless pulleys -

QUESTION: I'd like to be so presumptuous as to "correct" Col. Fought again, his worst-case scenario with respect to conventional weapons in Europe and Germany. You suggested that the problem you have is that the Germans get the nuclear weapons and not the Dutch. I would submit to you that's not a realistic scenario. First of all, there's no responsible German politician who wants nuclear weapons; there's certainly no political party in Germany that wants nuclear weapons for the Germans; thirdly, it would be politically impossible for a leader or party to advocate German ownership of nuclear weapons, because the political atmosphere in Germany would not tolerate it. It seems to me what we ought to be worried about is not the Germans would get control of nuclear weapons but that there would develop in Germany an increasing resistance to the idea of other people determining when and where nuclear weapons will be exploded on German territory. That will lead Germans to increasingly ask why they are putting themselves into this situation. Secondly, it seems to me that many Germans might begin to wonder why we should continue to spend the time and money and effort we are on defense when the Soviets are no longer such a challenge to us; why don't we just withdraw from NATO? It seems to me that's the thing we ought to be worried about, because then you've got a very different kind of calculation in conventional weapons.

Col. FOUGHT: Let me agree with your first point and say unequivocally that I hope you are correct on the first point. No doubt about it. On the second point, there are people within the defense specialist community that are worried about German neutralism, German neutrality, that's a real problem. You know the exercises that have been going on recently between France and Germany that are not NATO exercises, the questions that are being raised within German circles -- not just within SPD, and not because of some sort of political alliance with the Greens, but also within CDU -- the revisiting of the sixty-one to sixty-seven flexible response debate, and of other people being responsible for the nuclear decision, precipitated somewhat by the INF agreement. Those are real things that are happening, but my point though is that a nation as proud as the German people, and I speak of Germany now as all German-speaking people; I'll use the German term, the German expression of this, when they are wondering why are we letting other people be responsible for our own security, a possible outcome is that we shall be responsible for our own in ways attuned to the times. I think that is a legitimate concern for all people, in the United States and others, and it has to do with nuclear proliferation. Right now we've got a nuclear proliferation treaty, and Dr. Lall and I agree wholeheartedly on that: that's one of the best treaties that's ever been done. But there are certain possibilities that will have to be raised with this issue of German neutralism that's coming up. I don't think Germany's going out of the alliance; I think Germany is solidly behind the alliance. I don't think there's any question

about it right now. But there's some hiccups coming along that we're going to have to think about.

QUESTION: In the neutralism debate, it's not a question of whether Germans get nuclear weapons -- they're not talking about that; they're talking about, in many cases, the Greens for example are talking about disarmament, period.

Col. FOUGHT: Well, the Greens and British Labor and the alliance with Ken-  
nick -- I don't see that as being politically powerful. The labor alliance within  
Britain is getting discredited right now, it's even having to do with the railway and  
post office strikers, and the same thing, SPD and the alliance with the Greens, it's  
not a serious alliance once they take office. The larger decision to look at NATO  
right now is the 92 decision, with the European Economic Community that's a four  
point three commission; EEC's four point three and we're four point seven, you're  
looking at an economic power that's -- East Germany's backdoored into the 92  
decision by trading with West Germany, and now you're looking at an alliance that  
is politically and economically as powerful as ours. Now where is the nuclear  
authority in the crack? That's even more interesting than the neutralism decision,  
but that's not SDI, so maybe we shouldn't -- But I will not necessarily stand cor-  
rected on my concern, but I just hope you're right. Okay?

QUESTION: I am Colonel Thomas Foote. Dr. Lall said earlier that deploy-  
ment of SDI would be considered a violation of the ABM treaty, and I have heard  
for some time, and I'm sure everybody else has here, too, that many consider that  
the Soviets are already in violation of the ABM treaty with their Krasnoyarsk large  
array radar, which I don't understand, but would one of you comment on this aspect,  
and the true significance of this radar in the negotiation aspect?

Dr. LALL: Well, this radar, that's in Siberia, is, I think in the view of most  
people who've looked at it, a violation of the treaty because radars, under the ABM  
treaty, are supposed to be placed on the periphery and looking outward, and  
probably one of the reasons that it was put where it is, which is not on the periphery  
and looking outwards, was not because they were about to build an ABM battle  
management system and go to war, but because the terrain at that part of the world  
is so awful that it's extraordinarily difficult to build anything. Now the Soviets, be-  
cause we have hammered away at them, have offered to turn it into an internation-  
al space kind of activity that would be managed by, presumably, an international  
group. I think that's one offer that might be interesting to look at, rather than to  
say, Okay, you've got to tear it down. By the way, they stopped building it, and they  
have not gone ahead to finish it, and they have invited members of the U.S. Con-  
gress, as well as others, to look and inspect it, and those who have looked at it say  
that it's in lousy shape and it's not in a position to be a threat to anyone. But I would  
add, however, that the Soviets have pointed out, as well as many of us, in the United  
States -- the Soviets haven't made a big case of it -- that we are in violation of the  
treaty because the treaty says you are not to place your radars in foreign countries,  
and we are building radars in Greenland and Great Britain. There is an argument  
about whether this is modernization, and at what point modernization is permitted,



but I think if a group looked at that carefully, it would be quite a question in debate as to whether the United States isn't also in a kind of technical violation of the treaty (see Treaty Articles VII{b} and IX).

Col. FOUGHT: Let me add something to that. I think we should make a distinction between the facts in the case and what I would, I guess maybe rudely, call an apologist approach. The facts in the case are that the radars are supposed to be on the perimeter looking outward. The facts in the case are that Krasnoyarsk is on the interior -- not exactly on the interior, but essentially in the interior; it's in Siberia -- and it's looking inward, and it also happens to look over some missile fields. Now there is a reasonable explanation for that, that is offered by the Soviets, that has to do with soil. Those are explanations and excuses, those are not facts. It is up to you to determine whether or not it is truth. Okay. But there's reasonable grounds for it, let me say the other side of it, since I've been kind of sticky on that; let me say that there's also reasonable evidence to believe it. The now Greenland and Great Britian facilities? Now I'd be tempted to pull the treaty out here, because I don't remember the line about not building in foreign countries -- the line says on the periphery. Can anybody else verify --

Col. FOUGHT: So it's non-transfer, it's not in other countries. Let's get the line right. And I don't believe we've transferred. The things have no back -----; they are on the periphery, they do look out. The two are not related.

Dr. LALL: What would be helpful here is for the two sides, perhaps, each to pick two people, one from each side and the two sides to pick a third, and look at that and then come to a judgment. I do think it's very difficult in these bilateral treaties, when there's no provision for a third party judgment, that we constantly argue and debate these things and, under this system, can never reach some kind of determination. Sooner or later we're going to have to go that route.

Col. FOUGHT: Third party mediation, not third party arbitration -- there's a difference. But with third party mediation --

Dr. LALL: Both are used. I'm not saying that we should use arbitration in this case, but --

Col. FOUGHT: But mediation would help.

Mr. NOWLEN: We'll take two more questions --

Col. FOUGHT: And then we'll take a beer (laughter) --

QUESTION: Opponents and proponants of SDI have come out in favor of continued research and analysis -- what are the proponents and opponents arguing about all day today?

Dr. LALL: The proponents of SDI? or the opponents?



**QUESTION:** The opponents, like you, are in favor of continued research and analysis, which is going to take quite a while; the proponents are arguing for something, what is that they are arguing for, since everyone agrees that research should continue?

**Dr. LALL:** What is being argued here is that the SDIO organization and the Reagan administration have wanted to push the timetable up to the point where one or at least two of the tests outside the laboratory could be performed next year, and if we went ahead with that, that would be a clear violation, and so there are other tests also that are planned, outside the laboratory. In our study we've got a listing of over ten, so it's a real threat, not just a perceived one.

**Col. FOUGHT:** I personally think that with respect to that, the ABM treaty needs some revision between both ourselves and the Soviets to clear this up. When you're talking research, research goes research, development, testing, engineering, and then finally deployment, and I can make a good solid case that anything is basic research, and I can make a good solid case that anything is advanced development. The issue is what you can verify and what you can't. We need to sit down with ourselves and the Soviets and say, Okay, we're both doing the research, nobody's going to be able to stop doing the research until we can verify that each of us has stopped it. So where can we stop it? Now let's use the ABM treaty as a reasonable place, let's define where we can stop it, because right now the language, loose, strict interpretation, whatever, is essentially useless, because we can argue all sides of it. So let's work on exactly what it means, and we'll work it from the verification grounds. And we probably ought to work on extending the length of it too -- the abrogation clause right now is six months, which kind of gives both military communities an incentive to go fast because the other side's going fast -- you know, it's a handy excuse. Five year abrogation clause seems pretty reasonable -- it'll take that pressure off and that might be a good way to do it. Your question was, what are we arguing about? my essential argument is that we look at defense, offense, and negotiations in the same context and not just look at strategic nuclear but look at the theatre balance as well. You've got to look at the whole equation, that's my argument. I am tickled to death that those who have opposed SDI so viciously in the past have finally come around to say You've got to do the research and development, and now I think we're coming together to say, Okay, you've got to define where you can cut it off and where you can't -- that's a good debate, a good honest debate.

**Dr. LALL:** Let me just emphasize that I think it's quite clear in the treaty -- the line between doing research in the laboratory and going outside, and the latter is clearly prohibited; there are places in this treaty, about eight of them, that really ought to be looked at for a new effort at definition, for example there's no effort to make any clear definition of the word development. We suggest that between the laboratory and the engineering stage, that's development and when that treaty says that's banned, it's banned. But it's fuzzy -- there are a number of other places in the treaty where there ought to be a review to make a better definition than what

the treaty has in it now. That's for the future, hopefully, that the two sides will do that.

Col. FOUGHT: Agreed. We need the better definition, because the definitions are fuzzy.

Mr. NOWLEN: Last question? Then we will regard your question as the last for the evening. First, would you please help me thank Professor Fought and Doctor Lall.

Second, I know you agree that these are important conversations, and I hope you will help us continue them. On behalf of the University of Virginia, the Conference is adjourned. Good night.

## *Chymomyza amoena* (Diptera: Drosophilidae) in Virginia

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### ABSTRACT

*Chymomyza amoena* (Loew) has invaded apples in Virginia. Emergence has been documented from piedmont, southwestern, and Allegheny Mountain sites. Unripe rotting and unripe parasitized apples can provide oviposition substrates. Population size is small. Eggs are aggregated. Populations provide a model of Wright's demes. Rare and common polymorphisms exist. An eastern piedmont population displays genetic differentiation. Evidence for clinal speciation remains uncertain. Niche sharing with diverse insects, dipteran and nondipteran including major apple pests, has been found in all localities.

### INTRODUCTION

*Chymomyza amoena* (Loew) has been found to be breeding and overwintering in a variety of substrates in Michigan, including apples. Larvae can be found in unripe parasitized apples in June, ripe and rotting apples in fall and winter (Band and Band, 1980, 1982, 1984, 1987). Expansion into apples in Michigan dates from the 1890s (Band and Band, 1982). This species was found to be overwintering in orchard apples and breeding in unripe fallen frassy apples in the Danville-Eden area of VA/NC in 1984 (Band, 1985), where larvae may co-occur with other larvae of more species than in Michigan (Band, 1988a,b).

Population size is small. A maximum number of 25 individuals displaying (wing-waving) on fallen apples was counted at one Lansing, MI site in August, 1981; at an E. Lansing site in summer 1984 only 4 individuals were counted on fallen apples in the first week of July, August and September although apples with eggs can be obtained in early June (Band, 1988a,b). Small population size has bearing on theories in population genetics (Slatkin, 1987), and speciation (Mayr, 1963, 1982; Murray, 1972; Barton and Charlesworth, 1984; Carson and Templeton, 1984; Strong *et al.*, 1984). Niche sharing among drosophilids is of ecological interest (Wallace, 1975; Atkinson and Shorrocks, 1984; Gilpin *et al.*, 1986).

Small population size theoretically promotes genetic homogeneity; a larger population broken up into local breeding units or demes is subject to both the ef-



fects of genetic drift and interdemec selection leading to genetic differentiation. However, an exchange of even one individual between populations is sufficient to prevent genetic differentiation regardless of population size. Extinction and recolonization also retard the effects of genetic drift while selection for the same allele or same trait can produce geographic uniformity regardless of gene flow. Therefore population differentiation due to interdemec selection can be overcome by either natural selection or immigration (Slatkin, 1987).

The most important corollary to small population size is speciation. Mayr (1963, 1982) emphasized founder effects, genetic revolution, and rapid genetic changes resulting in reproductive isolation. Carson (1975) argued that widespread weedy species are less subject to founder effects speciation while Carson and Templeton (1984) reviewed more complex models of speciation developed for the specious Hawaiian *Drosophila* and for shifts from outbreeding to parthenogenetic forms. Barton and Charlesworth (1984) cast doubt on the genetic revolution models of speciation. Speciation models of Murray (1972) and Strong *et al.* (1984) are in the non-revolutionary mode. Reviewing Fisher's model of clinal speciation, Murray points out that populations at either end of a geographic cline may be reproductively isolated from one another yet able to share genes with intervening populations. Strong *et al.* merely argue that new species are not likely to evolve in time periods of less than a thousand years. They also point out that introduced plants are likely to be colonized by insects feeding on related native plants.

A native North American drosophilid, *C. amoena* breeds in native fruits and nuts, *Malus coronaria*, *Juglans nigra*, *Quercus* sp., and possibly native plums (*Prunus*). Plum curculio (*Conotrachelus nenuphar*) is also an endemic North American pest whose attacks on unripe fruits (plums, apples) typically precede early summer *C. amoena* oviposition (Band, 1988a,b). Niche sharing has bearing on aggregation (Atkinson and Shorrocks, 1984) and on invasion by other *Drosophila*. Atkinson and Shorrocks argued that fruit variation and species-specific female oviposition traits can affect egg clustering, hence the distribution of eggs over substrates in nature. Wallace and Gilpin *et al.*, reached different conclusions on *Drosophila* niche sharing from laboratory models. Gilpin *et al.* carried out a number of species-pairs comparisons but found that multispecies experiments supported only three species; Wallace found that *D. melanogaster* would take over any niche, if present.

In Michigan larval overwintering studies showed that by March proline accounted for over 50% of the free amino acids in the hemolymph of viable *C. amoena* larvae, but there was also a high mortality rate. This was reminiscent of genetic load arguments (Band and Band, 1987). It suggested the existence of a genetic polymorphism affecting a major energy pathway.

Work begun at Mt. Lake Biological Station, Giles Co., elevation 1200 m., in Virginia's Allegheny Mountains, in 1985 on Virginia *C. amoena* populations has focused on oviposition behavior in apples, allozyme polymorphisms, population differentiation, evidence for speciation, and niche sharing. Studies have been carried out only on summer populations, but demonstrate the widespread existence of this rarely observed species in the state. Evidence for a common allozyme polymorphism and for population differentiation is presented while evidence for clinal speciation remains inconclusive.

## MATERIALS AND METHODS

## Study Sites

Mountain Lake Area, Southwestern Virginia: In the first summer sites having apple trees along Route 700 to Mt. Lake Biological Station (MLBS) were identified as *C. amoena* breeding sites. These included Mt. Lake Hotel (MLH) which has 2 and 11 apple trees on opposite sides of Route 700, and two farms, approximately 3.5 and 4.0 km from the intersection of Route 700 and Highway 460, which have 5 and 4 apple trees, respectively. The farm with 5 trees has been labeled A; sampling has continued there. The farm with 4 trees has been labeled B, tree height made it difficult to sample fruits from trees, so use of this site was discontinued after 1985. The second summer, 1986, a noncommercial Blacksburg orchard was added as an established *C. amoena* breeding site. Apples were also collected from the tree on the Station grounds. Apples from trees along Route 604 at the base of Salt Pond Mountain and at Kelly Flats in Jefferson National Forest were sampled in 1987.

Virginia Piedmont Localities: In 1985 the Danville noncommercial orchard, which had apples containing overwintering *C. amoena* larvae in 1984, was sampled for infested apples in August. In 1986 apples were obtained from a farm near Pamplin and from a Danville neighborhood in June. Apples were also obtained from both localities in early July 1987.

Handling of substrates, including culture methods for emergees: *Chymomyza* eggs are distinctive (Throckmorton, 1962; Hackman *et al.*, 1970), and readily distinguished from those of *Drosophila* (subgenera *Sophophora*, *Drosophila*: Patterson and Stone, 1952) and lesser apple worm (*Grapholitha prunivora*). In 1985 and 1986 apples found to contain *C. amoena* eggs were placed individually in clear plastic cups over moistened vermiculite (potting soil), and capped with aluminum foil secured by a rubber band; this was done only for apples collected in the Mt. Lake area. Apples with *C. amoena* eggs from piedmont sites were grouped into pint-sized canning jars, capped with muslin, secured as before. This procedure was followed for all collections in 1987. In all years, emergees were transferred to population bottles either directly or via aspiration for further work. In 1985 and 1986 emergees continued to be maintained on commercial or collected apples + frass until return to East Lansing. In 1987, emergees were transferred directly to high protein medium (Band, 1988a).

## Observations and Experiments

In all years and at all sites, apples have been sampled from the ground and from the trees. This enables behavioral comparisons with Michigan *C. amoena* (Band, 1988a,b).

Oviposition and emergence: In 1985 apples were sampled between July 15 and August 15 at Route 700 sites (mid-July, late July and mid-August) and in August from the Danville site. Data on the location of eggs (stem, calyx, hole/scar, bract) and types of apples (frassy, nonfrassy, unripe, ripe, brown) have been included in Band (1988a). Cultures containing *C. amoena*-infested apples were transported back to Michigan to obtain complete records on emergence and for numbers of larvae pupating in soil versus substrate. For the latter, the vermiculite from each culture was transferred to a beaker of water. The number of pupae cases floating



to the surface provided the measure of larvae pupating in soil; subtraction from total emergees per culture gave the number in the substrate (Band, 1988a).

Oviposition choice among frassy (29 apples), ripe nonfrassy apples (21 apples) and brown rotting (2) apples among July-collected sample in 1985 prompted earlier collection dates in 1986. Apples were gathered at MLH and Route 700 A sites beginning June 20th, from Pamplin and Danville also in June, then three times during July from the Route 700 A and Blacksburg sites. Collected apples in southwestern Virginia were scored as brown (rotting), unripe (green) or ripe (1/3 red), frassy or nonfrassy; location and numbers of eggs per apple were recorded. Apples were dissected August 15th to determine the presence of frass, if not visible initially. Numbers pupating in soil versus substrate were determined as in 1985.

In 1987 three collections were made during July at the MLH, Route 700 A and Blacksburg sites. Apples gathered were unripe rotting, parasitized unripe or ripe except at the MLH site where there were few parasitized apples. Numbers of *C. amoena* eggs were recorded per apple. This enables a comparison of egg aggregation within and between years (Atkinson and Shorrocks, 1984). An August collection at Route 700 A provided information on the presence of new versus old *C. amoena* eggs on apples. Collections under trees along Route 604 at the base of Salt Pond Mountain and at Kelly Flats give additional data on *C. amoena* distribution in southwestern Virginia. All pooled samples per collection having *C. amoena* eggs were transported back to Michigan and held until October. Collections especially in 1985 and 1987 supply further data on other species also sharing the apple breeding niche in Virginia.

Numbers of adults seen at sites have also been recorded in all years.

Interpopulation crosses: Small mass matings among Michigan *C. amoena* from northern lower, mid and western Michigan were used to demonstrate lack of reproductive isolation; all Michigan populations were also interfertile with Missouri *C. amoena* (Band, 1988a). In 1985 reciprocal crosses between Michigan and Virginia flies were carried out using commercial apples supplied with frass as a substrate; as they emerged, flies were aspirated, sexed and transferred to the appropriate cross until 3 females and 3-to-4 males of desired parentage were achieved. In 1986 emergees were similarly aspirated, sexed and transferred to appropriate crosses to set up reciprocal matings between populations from different Virginia localities (Pamplin, Danville, Route 700 A, or population F<sub>1</sub>s) or F<sub>1</sub>s only (Blacksburg). Crosses were also made between Michigan and Virginia flies from the two piedmont locations. The increased number of crosses forced the use of only 2 females and 2 males per cross. Crosses at Michigan State University used high protein medium (Band, 1988a) and more flies per cross. The only stock successfully maintained after October, 1986 was from Pamplin. In 1987 reciprocal crosses between Route 700 and Blacksburg populations were carried out on medium.

Niche persistence: Much theory in population biology depends upon population stability (Gilpin *et al.*, 1986). Fruits themselves are highly seasonal. Major collecting sites were inspected in August 1987 or property owners questioned about the disposal of fruits in autumn, if not known. A visit to MLBS was also made in May 1988.



TABLE 1. Emergence of *Chymomyza amoena* adults from Virginia apples.

Location	Year	No. emerging
One Year		
Danville orchard	1985	4
Danville city	1986	68
Route 700 B farm	1985	16
Mt. Lake Biological Station	1986	7
Kelly Flats, Jefferson National Forest	1987	20
Route 604	1987	19
Two Years		
Mt. Lake Hotel	1985	31
	1987	35
Pamplin farm	1986	39
	1987	15
Blacksburg orchard	1986	15
	1987	36
Three Years		
Route 700 A farm	1985	48
	1986	36
	1987	146

TABLE 2. Oviposition site choice during July 1986 at Blacksburg (A) and mid-700 A (B) sites.

Color/Type of Apple	Frass Present		No Frass		Total	
	A	B	A	B	A	B
brown	3	3	6	13	9	16
green (unripe)	20	16	9	8	29	24
ripe	4	3	0	3	4	6
Totals	27	22	15	24	42	46

Allozyme polymorphism: Michigan *C. amoena* were assayed for polymorphisms affecting enzymes in the glycolytic pathway. Phosphoglucumutase, *Pgm*, was found to be polymorphic (Band and Band, 1987). Populations in Virginia were scored for *PGM* polymorphism in summer 1986 and also for rare alleles of alpha-glycerophosphate dehydrogenase, *a-Gpdh*, and malic enzyme, *Me*. Adults and larvae, including F<sub>1</sub>s, were used to increase numbers. Populations were also scored

for polymorphisms in 1987. *PGM*, *a-GPDH* and *ME* allozyme tests were carried out. Buffers, gels and staining procedures are as described in Werth (1985) or in Band and Band (1987).

Data analyses: Sokal and Rohlf G-statistics, Poisson distribution, means and negative binomial *k* values, and the analysis of variance have been performed via the Sokal and Rohlf Stat Pak.

## RESULTS

**Emergence:** As shown in Table 1, *C. amoena* adults have emerged from gathered apples at only one site all three summers. Some sites are ephemeral: the tree on the Station grounds did not produce apples in 1985. Larvae may fail to develop: apples collected from the same trees sampled in 1986 as in 1985 at the MLH site, and Danville city site in 1987 had eggs or larvae but yielded no adults. Some sites have been sampled only once: Danville orchard and Route 700 B in 1985, Kelly Flats and Route 604 sites in 1987. Some sites were not sampled in 1985: Pamplin, Danville city and Blacksburg sites.

Numbers of adults emerging are low regardless of the locality, general drought in 1986, or the southwestern drought in 1987. Nevertheless, the emergence of this species from apples at multiple sites in piedmont and southwestern Virginia indicates an extensive invasion of apples in the state.

Numbers of adults visible at any one time are negligible. Five adults were seen on apples at the Danville city site in June 1986, only one at Route 700 A in mid-July 1986, none at Blacksburg, none at MLH on apples. At the Station 4 adults displayed on fresh cut firewood between mid and late July 1985 and a few were observed fighting on apples on the ground by late July 1986. In 1986 one adult was attracted to a light trap; 3 adults were caught in grass sweeps by the Entomology Class and one at Bald Knob between mid and late July; the author trapped one on wild cherry (*Prunus*) in July 1986.

**Oviposition:** Oviposition is predominantly on fallen fruits. However females will oviposit on damaged fruits on trees. In 1985, at both a Route 700 site and in Danville, 4 apples contained 20 *C. amoena* eggs. In 1986 5 apples contained 13 eggs from Blacksburg, Route 700 and Station apple trees. In 1987, again the Blacksburg and Route 700 sites had 7 apples on trees which contained 15 *C. amoena* eggs. All apples had been parasitized except those on the Station grounds which developed splits. *Chymomyza amoena* females in Michigan likewise oviposit on fruits on trees (Band, 1988a,b).

Oviposition preference in southwestern Virginia in July is for rotting unripe frassy apples or firmer unripe parasitized apples, as shown in Table 2. Females make more use of the former type of apple along Route 700 than at Blacksburg, or else the brown unripe rotting apples are more readily available. The three way G-test shows the following tests of independence are significant: site x apple x frass (d.f. = 7,  $G = 22.93$ ,  $P < 0.005$ ), site x frass (d.f. = 1,  $G = 7.15$ ,  $P < 0.01$ ), and apple x frass (d.f. = 2,  $G = 12.54$ ,  $P < 0.005$ ). When first collections were inspected in early July 1987, oviposition was on parasitized unripe fallen apples at Blacksburg (20) and Route 700 A (11), whereas at MLH, oviposition was mostly on brown rotting nonparasitized apples (43). Approximately half or fewer apples

TABLE 3. Comparison of means and negative binomial  $k$  values for egg deposition on apples in 1986 and 1987.

Year	Location	Month	Sample	N	mean	k
1986	Pamplin	June	1	95	0.29	0.303
		June	1*	62	1.37	0.346
	Blacksburg	July	1	73	0.40	0.055
			2	71	0.28	0.060
			3	51	1.76	0.467
	Route 700 A	June	1	58	0.59	0.051
			1	27	3.04	0.395
		July	2	25	4.80	0.311
			3	24	10.50	0.373
1987	Blacksburg	July	1	52	1.86	0.229
			2	76	0.86	0.210
			3	109	0.90	0.262
	Route 700 A	July	1	41	1.07	0.144
			2	90	3.96	0.298
			3	69	0.78	0.051
	Hotel	July	1	156	0.62	0.201
			2	78	0.82	0.147
			3	35	0.34	0.117

\* 2 samples in June combined

gathered in the initial collection in 1987 were used for oviposition, from the data given in Table 3.

Egg aggregation: Table 3 shows the total number of apples per collection, mean number of *C. amoena* eggs per apple and negative binomial  $k$  values for 1986 and 1987 collections. Poisson distributions fitted to distributions of eggs at Pamplin, Danville, and initial collections at the Blacksburg and Route 700 sites in 1986 produced highly significant chi-square values. Atkinson and Shorrocks (1984) have argued that the negative binomial gives the better fit for aggregated data. Goodness of fit tests using estimated  $m$  and  $k$  values for each collection in Table 3 support their argument, as observed in Michigan studies (Band, 1988b). When Virginia collections are compared, there are no significant differences in initial samples in 1986 in mean number of eggs or negative binomial  $k$  values among the 2 piedmont and 2 southwestern Virginia sites. The 2-way ANOVA shows the negative binomial  $k$  values do not differ significantly between sites or between years for southwestern Virginia sites samples in both 1986 and 1987. Means also do not differ significantly between years, or between sites when the interaction mean square is used in the denominator. The 1987 data also yield no significant differences for means or binomial  $k$  values among sites in southwestern Virginia. Numbers of adults emerging, shown in Table 1, do not reflect the considerably larger number of eggs present. However, in the final August Route 700 A collection, 12 apples



TABLE 4. Comparison of fertility between reciprocal crosses from Virginia localities in 1986.

females	Cross males	No. F1s	Fertile?
Pamplin	Danville	30	yes
Danville	Pamplin	5	yes
Pamplin	Blacksburg	24	yes
Route 700 A	Danville	4	yes
Route 700 A	Blacksburg	18	yes
Blacksburg	Route 700 A	22	yes
Route 700 A	Pamplin	none	
Pamplin	Route 700 A	none	

had a total of 134 *C. amoena* eggs, of which 29 were new; 33 collected apples lacked eggs. This agrees with laboratory studies and Michigan natural population studies suggesting females may oviposit where *C. amoena* eggs already exist (Band, 1988a,b).

**Pupuration:** Larvae pupate in soil or in the substrate. Of the 41 flies emerging from MLH and Route 700 apples collected in mid-July 1985, 30 remained in the substrate and 11 migrated to the soil. *Drosophila* emerging from later collections complicated data on *C. amoena* in 1985 (see Table 6). In 1986 no *Drosophila* emerged from the collected apples at Route 700 A. Of the 36 *C. amoena* emerging, 16 remained in the apples and 20 pupated in soil. Differences between years are significant ( $d.f = 1$ ,  $G = 6.66$ ,  $P < 0.01$ ).

**Niche persistence:** Only one major sampled site has the potential to provide apples as a breeding substrate year-round. Wildlife had eaten the dropped apples at MLH by mid-August 1987 from the presence of rabbit pellets and deer droppings. At Route 700 A dropped apples are disposed of in fall. At the Blacksburg orchard, cattle graze in the large fenced area; however, dropped apples are no longer gathered in fall from the unfenced area. Apples are continually discarded throughout the summer in Danville, those remaining in fall at Pamplin are buried. In May in the MLBS area, apples are still forming and had not begun to fall in May.

**Interpopulation crosses:** Table 4 presents the results of crosses among Virginia populations in 1986: Pamplin, Danville, Blacksburg and Route 700 and follow-up crosses between Route 700 and Blacksburg crosses in 1987. Reciprocal crosses between the two piedmont localities, Pamplin and Danville, gave fertile F<sub>1</sub>s. Crosses between Pamplin females and Blacksburg males and between Route 700 females and Danville males also gave fertile F<sub>1</sub>s. Reciprocal crosses between Route 700 and Pamplin flies were not fertile. These were repeated in October with the same results. However, Route 700, Blacksburg, and Danville stocks all failed to become established. In 1987 failure of both Danville and Pamplin populations made it impossible to repeat the observations. Crosses between Michigan and Pamplin populations gave fertile F<sub>1</sub> hybrids as did the cross between Michigan females and Danville males. Only 2 progeny resulted from the Danville/Michigan cross.

TABLE 5. Allele frequencies of three loci in two piedmont and two southwestern Virginia *C. amoena* populations in 1986 and 1987.

Piedmont											
Pamplin						Danville					
<i>Gpdh</i>		<i>Me</i>		<i>Pgm</i>		<i>Gpdh</i>		<i>Me</i>		<i>Pgm</i>	
86	87	86	87	86	87	86	86	86	86	86	86
F +				.001	.78						
F				.800	.22					.68	
N(M)*	1		.97	.90	.199	0	1	.91		.32	
S			.03	.10				.09			
n	33		32	5	33	9	22	22		22	
het.	0		.03	.10	.21	.22	0	0		.19	
Southwest											
Blacksburg						Route 700 A					
<i>Gpdh</i>		<i>Me</i>		<i>Pgm</i>		<i>Gpdh</i>		<i>Me</i>		<i>Pgm</i>	
86	87	86	87	86	87	86	87	86	87	86	87
F +											.02
F				.78	.30	.04		.07		.67	.47
N(M)*	1	1	1	1	.22	.70	1	.94	.96	.88	.33
S							.01	.04	.05		.02
n	24	11	25	20	25	20	24	72	23	41	24
het.	0	0	0	0	.35	.20	0	.01	.04	.10	.25

\*N denotes the normal alleles for *Gpdh* and *Me*; M denotes the third fastest migrating allele in the *Pgm* series.

Allozyme comparisons: Comparison of *Pgm* allele frequencies among the 4 populations sampled in 1986 demonstrated that all had similar frequencies of *Pgm-F* (74%) and *Pgm-M* (26%) alleles (Band and Band, 1987). Genotypic values differ significantly (Band, 1987). The Pamplin population had no *Pgm-M* homozygotes. Later analyses of the Pamplin stock continued to demonstrate a lack of *Pgm-M* homozygotes. The erratic emergence of Pamplin flies in 1987 over a month made it impossible to establish a 1987 laboratory population or confirm the persistence of the lethal-carrying *Pgm-M* allele in that population. A 1987 Blacksburg stock demonstrated a considerable proportion of *Pgm-M* homozygotes in the laboratory by November. However, the overall frequency of *Pgm-F* in 1987, 52%, is significantly lower ( $P < 0.005$ ) than in 1986, and fell in both Blacksburg and Route 700 populations, as shown in Table 5. *F* + and *S* alleles were recovered also in these populations in 1987.

In contrast to the high level of polymorphism for *Pgm* alleles, rare variants exist for *a-Gpdh* and *Me*. This is shown in Table 5. A slow allele at the *Me* locus was present in both piedmont and Route 700 populations in 1986 and recovered again

TABLE 6. Additional species emerging from apples yielding *C. amoena* in 1985, 1986 and 1987.

Year	Location	Collected	Other Species		
			Drosophilid	Pests	Other
1985	Danville orchard Route 700 A	mid-August	<i>melanogaster</i>	c.m.	
		late July	<i>affinis</i> <i>immigrans</i> <i>melanogaster</i> <i>melanogaster</i>	l.a.w. a.m.	
	MLH	mid-August			
		mid-July		p.c.	
		late July		p.c.	
		mid-August	<i>affinis</i> <i>immigrans</i> <i>melanogaster</i> <i>quinaria</i>		
1986	Danville city	June			diastatids
1987	Pamplin	July		c.m. l.a.w.	diastatids
	Danville city Blacksburg Route 700 A	July early July mid-July	<i>melanogaster</i>  <i>affinis</i> <i>immigrans</i> <i>melanica</i> <i>robusta</i>	  l.a.w. c.m. a.m. l.a.w.	  <i>Lonchaea</i>
	MLH Kelly Flats	 late July	<i>Chymomyza</i> sp. <i>affinis</i> <i>immigrans</i> <i>melanica</i>	  p.c.	 s.m.

a.m. = apple maggot; c.m. = codling moth; l.a.w. = lesser apple worm;  
p.c. = plum curculio; s.m. = small moth.

in 1987 in the two most widely separated populations subjected to electrophoretic analyses, Pamplin and Route 700. A fast *Me* allele was also recovered in the latter population as were fast and slow alleles for *a-Gpdh*.

Niche sharing with other species: Table 6 summarizes the species that have also emerged from apples found to contain *C. amoena* eggs. In 1985 *D. melanogaster* became present by mid-August at all collecting sites. In two localities it was the only other drosophilid present at that late summer date: Danville orchard and Route 700. In contrast to emergence of both drosophilids and pest species from 1985 apples, the drought in 1986 appears to have lowered survivability. Only apples from Danville yielded *Drosophila* and other species. Although little is known about diastatids (Borror *et al.*, 1981), these have emerged from apples in both piedmont localities. In 1987 *D. melanogaster* emerged from apples collected in two localities in the MLBS vicinity: Route 700 and Kelly Flats. An unknown drosophilid, tentatively labeled a *Chymomyza* because of its wing-waving (and



similar to a species so labeled in the VPI&SU Entomology collection) emerged from MLH apples. Flies identified as *Lonchaea* sp., normally sap feeders, emerged from Route 700 apples in addition to other *Drosophila* and pest species. Emergence of apple maggot adults in 1985 and again in 1987, in addition to seeing adults in the Danville orchard, establishes that this species is in Virginia.

## DISCUSSION

When the colonists arrived in Virginia, the woods and forests abounded with fruit and nut-bearing trees. They brought the commercial (domestic) apple with them. Strong *et al.* (1984) have argued that insect invasion of introduced plants is mediated by proximity, and taxonomic, phenological, biochemical and morphological similarity to native species. Jefferson (1792) lists *Malus coronaria* (crabapples), *Juglans nigra* (black walnut) and *Quercus* sp. (oaks) among Virginia's native trees. They also provide fruits and nuts that serve as *C. amoena* larval feeding/overwintering sites (Band and Band, 1984, 1987). Jefferson (Betts, 1944) also notes that weevils were attacking peaches, plums, apricots and nectarines by 1791. Hence in the east, *C. amoena* invasion of apples can well predate Michigan's established date of 1891.

Furthermore, given the longer growing season in the eastern versus southwestern part of the State, and the greater variety of apples, Virginia *C. amoena* provides a model of Wright's larger population broken up into smaller local breeding units, subject to varying climatic regimes and varying safety in the apple niche. Only the Blacksburg site has the potential to provide a continuous supply of new season's and past season's apples, and the population there is not reproductively isolated. Thus despite the readiness with which other sites can be sampled yearly, each local population is probably part of an area continuum. Long distance migration is sometimes mandatory (Coyne *et al.*, 1987; Coyne and Milstead, 1987).

In contrast to oviposition on firm unripe parasitized apples in Michigan (Band, 1988a,b), southwestern Virginia *C. amoena* females make significantly more use of brown unripe rotting apples. These are not unlike soft overwintered Michigan *Malus coronaria* crabapples in appearance. Overall, however, egg aggregation shows no difference between sites or years. Field studies indicate that females may oviposit where others of their species have oviposited; low population density and experiments using single pairs also suggest that females may lay more than one egg at a time (Band, 1988a). Therefore brown rotting and unripe firm parasitized fruits increase the variety of fruits available without affecting other species-specific oviposition traits. Nevertheless, whether aggregation over ephemeral resources promotes coexistence among species remains controversial (Green, 1988; Shorrocks and Rosewell, 1988; Worthen and McGuire, 1988) although in the use of unripe firm parasitized fallen fruits, *C. amoena* displays interspecies dependency (Band, 1988b).

There is some evidence that emergees from the brown rotting unripe fruits may not be fertile. Reciprocal crosses from Michigan and Virginia flies from MLH unparasitized apples in 1985 failed to produce progeny; crosses became fertile when the appropriate sex emerging from Route 700 A or B apples were added. Since the MLH population is the one most subject to wildlife predation, fertility or

sterility is of little consequence. In 1986, reciprocal crosses between Michigan and Pamplin emergees were likewise fertile (Band, 1988a).

More interesting are the results of crosses between flies from different Virginia localities. Despite low numbers, crosses show that gene exchange is possible between the eastern piedmont and southwestern halves of the analyzed population distribution. However, no progeny resulted from crosses between Pamplin and Route 700 A demes; eggs laid failed to hatch. Further evidence for what may be an example of *C. amoena* clinal speciation (Murray, 1982) has been elusive, due to laboratory failure of both populations. Murray's treatment of clinal speciation is comparable to Dobzhansky's (1951, p. 205) definition of allopatric speciation brought about by adaptation to different climatic environments and exemplified by Moore's (1949) work with geographical races of *Rana pipens*. Mayr (1982) subsumes allopatric speciation into his founder effects-genetic revolution model which would not account for interfertility among adjacent demes. However, given that Michigan, Missouri and Virginia *C. amoena* are also interfertile (Band, 1988a), Carson's (1975) hypothesis that widespread weedy species are not prone to speciate may also apply to widely dispersed opportunistic invaders inhabiting highly seasonal climates. Within Virginia more sessile insects as crickets have speciated (Harrison, 1985; Howard, 1986).

More apparent is the evidence that populations can become differentiated. Again the Pamplin population is implicated. Lethality associated with an allozyme polymorphism may be a means of retaining heterozygosity (Ives and Band, 1986). The *Pgm-F* and *Pgm-M* alleles represent a common polymorphism in Michigan and are highly subject to allele frequency shifts between summer and winter in Michigan (Band and Band, 1987). This is a common polymorphism in all Virginia populations sampled and in the Pamplin population, the easternmost *C. amoena* deme, *Pgm-M* carries a lethal (Band, 1987). However, the increased frequency of *Pgm-M* in both southwestern Virginia populations in 1987 and in Michigan *C. amoena* indicates that between year variation can be considerable.

The existence of rare alleles at both the *Pgm* and other loci supports the idea that gene exchange is possible between populations. Certainly there is no evidence from either rare or common alleles that small population size has promoted genetic homogeneity. *Chymomyza amoena* has been captured at lower altitudes by plane (Glick, 1939), so are certainly subject to extremely long-distance air current dispersal.

Niche sharing reveals the presence of apple maggot (*Rhagoletis pomonella*) in Virginia. In fact, major apple pests (plum curculio, codling moth, lesser apple worm and apple maggot) have emerged from apples in which *C. amoena* females also oviposited. Among drosophilids emerging, there can be considerable differences in species assemblages between years, between sites and within sites between seasons. Although the evidence in 1985 tentatively supports Wallace (1975) that *D. melanogaster* will outcompete other species once it enters a system, the consistent finding that *D. affinis* breeds in less highly fermented, tart apples suggests that substrate preference may also be a factor. Since assemblages have included both endemic and cosmopolitan drosophilids, pairwise comparisons under more crowded conditions of laboratory cultures (Gilpin *et al.*, 1986) may give misleading results about survival in natural habitats. Within collections more than 3



drosophilids frequently share the substrates, again questioning the applicability of their multispecies laboratory work to the natural habitat, as they also have done (Gilpin *et al.*, 1986). The repeated emergence of a sap feeding dipteran in the genus *Lonchaea* from apples at a Route 700 site in 1987 calls into question the reasons for host switching (Strong *et al.*, 1984; Mayr, 1963). Shorrocks (1977)'s findings that European drosophilids could be classified into two broad categories, fungal and sap/fruit breeding, may be relevant to other dipterans. *Lonchaea* have emerged from overwintered apples at a protected site in Michigan (Band, 1989).

Earlier collections in the Great Smokies in Tennessee (Carpenter and Giordano, 1955) and in the Blue Ridge Mountains of North Carolina (Miller and Weeks, 1964) failed to record *C. amoena* among drosophilids present even at lower elevations. Both investigations employed fermented banana bait. However, *C. amoena*'s preference for unripe or ripe unfermented fruits and their low population numbers may have led to the concealment of this species among the apple breeding insects in the South. Rarely observed, even as adults, their widespread distribution as determined by oviposition/emergence data suggests that overall they are not rare among the insects in Virginia.

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#### LITERATURE CITED

- Atkinson, W and Shorrocks, B. 1984. Aggregation of larval Diptera over discrete and ephemeral breeding sites: the implications for coexistence. *Amer. Nat.* 124: 336-351.
- Band, H. T. 1985. Is *Chymomyza amoena* a domestic species? *Genetics* 110: s8-s9. (Abstract).
- \_\_\_\_\_. 1987. *Pgm* in Virginia *Chymomyza amoena* populations. *Dros. Inf. Serv.* 66: 16-17.
- \_\_\_\_\_. 1988a. Host shifts of *Chymomyza amoena* (Diptera: Drosophilidae). *Amer. Midl. Nat.* 120: 163-182.
- \_\_\_\_\_. 1988b. *Chymomyza amoena* (Diptera: Drosophilidae), an unusual urban drosophilid. *Va. J. Sci.* 39: 242-249.



- \_\_\_\_\_. 1989. More on *Drosophila* overwintering. Dros. Inf. Serv. 69 (in press).
- Band, H. T. and Band, R. N. 1980. Overwintering of *Chymomyza amoena* larvae in apples in Michigan and preliminary studies on the mechanism of cold hardiness. *Experientia* 36: 1182-1183.
- \_\_\_\_\_. and \_\_\_\_\_. 1982. Multiple overwintering mechanisms by *Chymomyza amoena* (Diptera: Drosophilidae) in Michigan and laboratory induction of freeze tolerance. *Experientia* 38: 1448-1449.
- \_\_\_\_\_. and \_\_\_\_\_. 1984. A mild winter delays supercooling point elevation in freeze tolerant *Chymomyza amoena* larvae (Diptera: Drosophilidae). *Experientia* 40: 889-891.
- \_\_\_\_\_. and \_\_\_\_\_. 1987. Amino acid and allozyme changes in overwintering *Chymomyza amoena* (Diptera: Drosophilidae) larvae. *Experientia* 43: 1027-1029.
- Barton, N. H. and Charlesworth, B. 1984. Genetic revolutions, founder effects and speciation. *Annu. Rev. Ecol. Syst.* 15: 133-164.
- Betts, E. M. 1944. Thomas Jefferson's Garden Book, 1766-1824. xiv + 704 pages. Amer. Phil. Soc., Philadelphia.
- Borror, D. J., DeLong, D. M. and Triplehorn, C. A. 1981. An Introduction to the Study of Insects. xi + 827 pages. Saunders, Philadelphia.
- Carpenter, J. M. and Giordano, J. F. 1955. Populations of the genus *Drosophila* in the Great Smoky Mountains, Tennessee. *Amer. Midl. Nat.* 54: 104-118.
- Carson, H. L. 1975. Genetics of speciation at the diploid level. *Amer. Nat.* 109: 83-92.
- Carson, H. L. and Templeton, A. R. 1984. Genetic revolutions in relation to speciation phenomena: the founding of new populations. *Annu. Rev. Ecol. Syst.* 15: 97-131.
- Coyne, J. A., Bryant, S. H., and Turelli, M. 1987. Long-distance migration of *Drosophila*. 2. Presence of desolate sites and dispersal near a desert oasis. *Amer. Nat.* 129: 847-861.
- Coyne, J. A. and Milstead, B. 1987. Long-distance migration of *Drosophila*. 1. Dispersal of *D. melanogaster* alleles from a Maryland forest. *Amer. Nat.* 130: 70-82.
- Dobzhansky, T. 1951. Genetics and the Origin of Species. x + 364 pages. Columbia University Press, New York.
- Enomoto, O. 1981. Larval diapause in *Chymomyza costata* (Diptera: Drosophilidae). I. Effects of temperature and photoperiod on development. *Low Temp. Sci., Ser. B.* 39: 21-29.
- Gilpin, M. E., Carpenter, M. P. and Pomerantz, M. J. 1986. The assembly of a laboratory community: multispecies competition in *Drosophila*. pp. 23-40 in J. Diamond and T. J. Case, (eds.). *Community Ecology*. Harper and Row, Cambridge.
- Glick, P. A. 1939. The distribution of insects, spiders and mites in the air. USDA Tech. Bull. No. 673: 1-57.
- Green, R. F. 1988. Reply to Shorrocks and Rosewell. *Amer. Nat.* 131: 772-773.
- Hackman, W., Lackovaara, S., Saura, A., Sorsa, M. and Vepsalainen, K. 1970. On the biology and karyology of *Chymomyza costata* Zetterstedt with reference to

- the taxonomy, and distribution of various species of Chymomyza (Diptera: Drosophilidae). *Ann. Ent. Fenn.* 36: 1-9.
- Harrison, R. G. 1985. Barriers to gene exchange between closely related cricket species. II. Life cycle variation and temporal isolation. *Evolution* 39: 244-259.
- Howard, D. J. 1986. A zone of overlap and hybridization between two ground cricket species. *Evolution* 40: 34-43.
- Ives, P. T. and Band, H. T. 1986. Continuing studies on the South Amherst (MA) *Drosophila melanogaster* population during the 1970's and 1980's. *Evolution* 40: 1289-1302.
- Jefferson, Th. 1782. Notes on the State of Virginia. Wm. Peden (ed.). xxv + 315 pages. Univ. of North Carolina Press, Chapel Hill.
- Mayr, E. 1963. Animal Species and Evolution. xiv + 797 pages. Belknap Press, Cambridge.
- \_\_\_\_\_. 1982. Speciation and macroevolution. *Evolution* 36: 1119-1132.
- Miller, D. D. and Weeks, L. 1964. *Drosophila* collections near the Blue Ridge of southwestern North Carolina. *Amer. Midl. Nat.* 72: 93-114.
- Moore, J. A. 1949. Patterns of evolution in the genus *Rana pipiens*. pp. 315-338 in G. L. Jepsen, E. Mayr, and G. G. Simpson (eds.). *Genetics, Paleontology, and Evolution*. Princeton University Press, Princeton, N. J.
- Murray, J. J. 1972. Genetic Diversity and Natural Selection. viii + 128 pages. Oliver and Boyd, Edinburgh.
- Patterson, J. T. and Stone, W. S. 1952. Evolution in the genus *Drosophila*. 610 pages. Macmillan, New York.
- Shorrock, B. 1977. An ecological classification of European *Drosophila* species. *Oecologia* 26: 335-345.
- Shorrock, B. and Rosewell, B. 1988. Aggregation does prevent competitive exclusion: A response to Green. *Amer. Nat.* 131: 765-771.
- Slatkin, M. 1987. Gene flow and the geographic structure of natural populations. *Science* 236: 787-792.
- Strong, D. R., Lawton, J. L., and Southwood, Sir Richard. 1984. *Insects on Plants*. vi + 313 pages. Blackwell Scientific, London.
- Throckmorton, L. H. 1962. The problem of phylogeny in the genus *Drosophila*. *Univ. of Texas Publ.* 6205: 207-343.
- Wallace, B. 1975. The biogeography of laboratory islands. *Evolution* 29: 622-635.
- Werth, C. 1985. Implementing an isozyme laboratory at a field station. *Va. J. Sci.* 36: 53-76.
- Worthen, W. B. and McGuire, T. R. 1988. A criticism of the aggregation model of coexistence: Non-independent distribution of dipteran species on ephemeral resources. *Amer. Nat.* 131: 453-458.

## Short Term Temporal and Spatial Variability of Chlorophyll *a* Concentrations in the Elizabeth River, Virginia

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### ABSTRACT

A study of phytoplankton chlorophyll *a* variability in the Elizabeth River indicated spatial distances of from 6-14 km between stations had a greater effect on biomass variability than temporal daily or weekly changes in the physico-chemical environment. Slack water conditions also had a significant ( $<0.001$ ) effect on chlorophyll *a* distributions, with higher values during slack-before-flood, or low water periods.

### INTRODUCTION

Natural phytoplankton populations are known to exhibit variability in composition and abundance in response to changing environmental conditions (Cassie, 1963; Margalef, 1967; Platt *et al.*, 1970; Harris, 1980, 1984). In estuarine systems, characteristic tidal phenomena provide an additional dimension of change to influence physical and chemical parameters over a relatively short time period (Rice & Ferguson, 1975; Sinclair, 1978). The generation of micro-to mesoscale biomass patches has also been related to tidal conditions, that include the water exchange ratio, degree of turbulence, water density and stratification, light availability, and nutrient concentrations (Turpin and Harrison, 1979; Sinclair 1978; Sinclair *et al.*, 1981; Haffner *et al.*, 1980; Pennock, 1985). For instance, turbulence will directly govern chlorophyll distribution at patch sizes of less than 100m (Powell *et al.*, 1975; Platt, 1972; Okubo, 1974).

The purpose of this study was to evaluate the relationships between short term temporal and spatial differences of estuarine chlorophyll *a* concentrations and specific environmental parameters. The station locations are in the Elizabeth River which is part of the James River drainage basin which enters the Hampton Roads Harbor complex adjacent to the lower Chesapeake Bay. It is a shallow ( $>5$ m) tidal river system that is located within the port complex adjacent to Norfolk, Virginia, and consists of 3 major branches. A companion paper to this report emphasizes



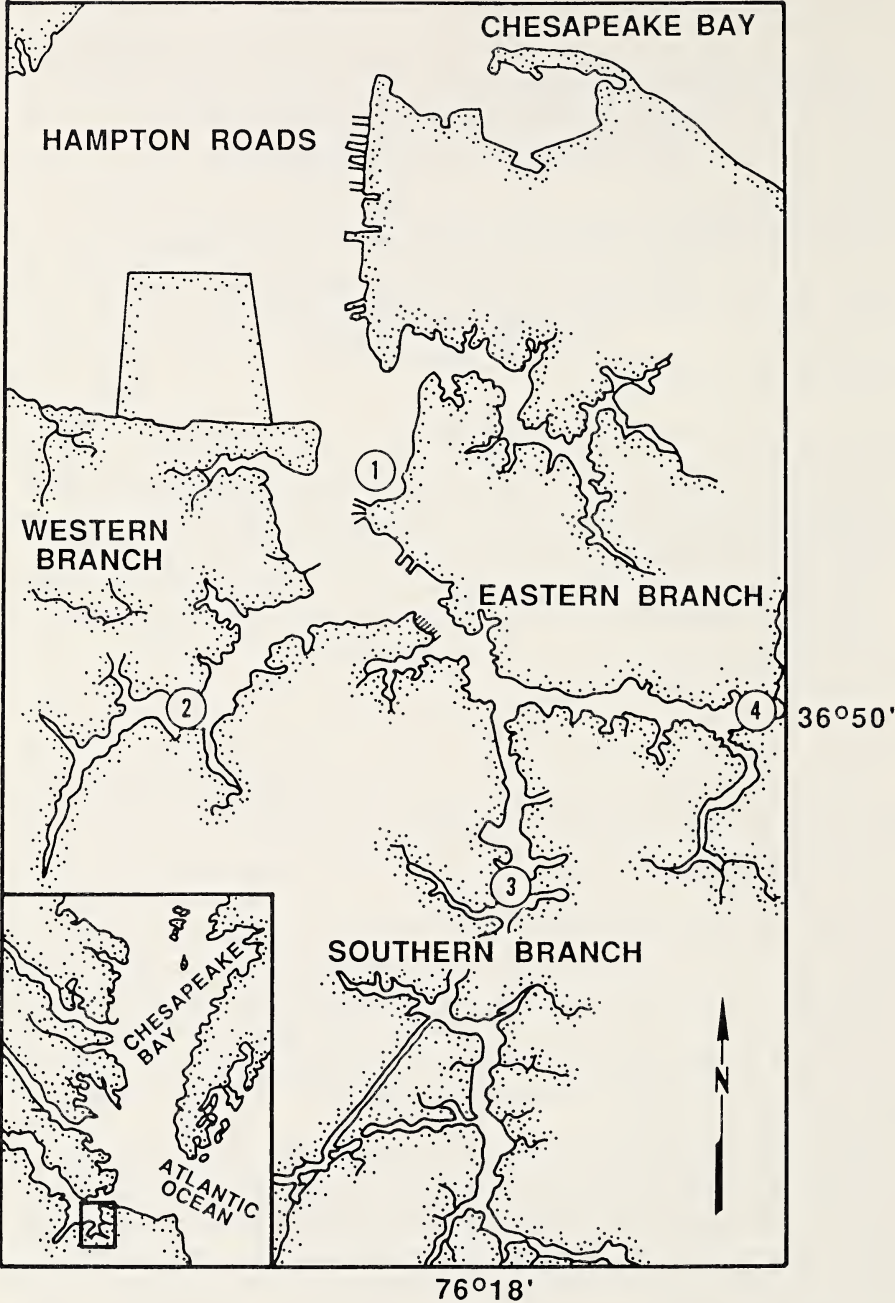


FIGURE 1. The Elizabeth River with station locations in the main stem (1), Western Branch (2), Southern Branch (3) and Eastern Branch (4).

species composition and spatial relationships for the phytoplankton assemblages in these branches (O'Reilly and Marshall, 1988). Past studies in the Elizabeth River have shown spatial differences of phytoplankton biomass, in addition to identifying diel, seasonal and annual fluctuations in chlorophyll *a* (Neilson, 1975; Neilson and Sturm, 1978; Cerco and Kuo, 1981; Adams *et al.*, 1977). The joint effect of temporal and spatial variability on phytoplankton chlorophyll *a* in this estuarine system has not been investigated.

## METHODS

Four stations were established in three branches of the Elizabeth River (Figure 1). These were sampled at approximately weekly intervals from October to December 1984. Distance between stations ranged from 6 to 14 km. Water samples were taken with a 2.5 l Niskin bottle at the surface and 0.5 m above the bottom for nutrient, chlorophyll and phytoplankton analysis. A 250 ml subsample was preserved in Lugol's solution for phytoplankton analysis, using a modified Utermohl method (Marshall and Lacouture, 1986). All nutrient concentrations were determined colorimetrically as follows: orthophosphate by the manual 2-Reagent ascorbic acid method; ammonia with the automated alkaline phenol and nitrate by conversion to nitrite using a copper/cadmium reduction column according to procedures given by EPA (1979) and the Orion Scientific Corp. (1977, 1981). Dissolved oxygen was determined using the azide modification of the Winkler titration using phenyl arsine oxide as the titrant (APHA, 1985). Salinity was measured with a Guildline salinometer (model 8400A). Triplicate filtrations (0.45  $\mu$ m Gelman type A-E, 25 mm filters) for total unfractionated chlorophyll *a* measurements were determined fluorometrically on 90% acetone extractions with a Turner Designs (model 10) fluorometer (Strickland and Parsons, 1972). Secchi Disk (22 cm) readings were used to determine the photic zone depth (Holmes, 1970).

The chlorophyll *a* data analysis was structured to fit a four-way fixed main effect analysis of variance (ANOVA) with replication (Sokal and Rohlf, 1981). As depth in this study was not significant in a preliminary model, a 3-way Model I ANOVA was performed using the Statistical Package for Social Sciences (SPSS). Treatments were time of day, week and station.

A stepwise multiple regression containing dummy variables was performed using SPSS to summarize and decompose the linear dependence of chlorophyll *a* on the following independent variables: week of sampling, time of collections, station location, and tidal current stage. The chlorophyll *a* collections corresponded to four tidal current periods: slack-before-flood, flood, slack-before-ebb, and ebb. Corrected tidal current tables for 1984 (NOAA) for the Chesapeake Bay entrance, along with current speeds and time differences for the Elizabeth River, were used to calculate time and duration of currents and slack periods.

## RESULTS AND DISCUSSION

The mean station depths ranged from 3 to 4.5 m. The euphotic zone (Zeu) depth extended to the bottom at stations 1 and 3 and was generally above bottom at stations 2 and 4. Station 2 and 4 were consistently more turbid having higher

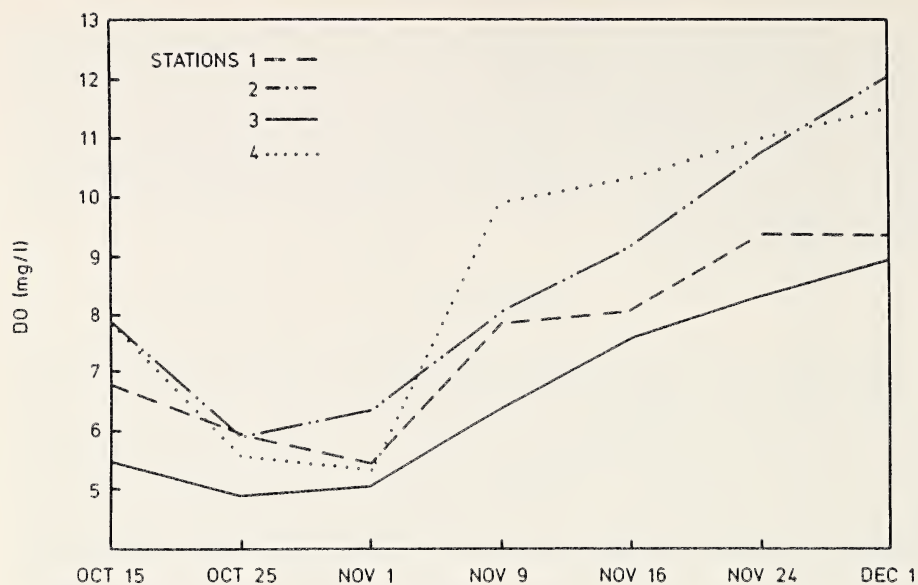


FIGURE 2. Dissolved oxygen (DO) concentrations at stations 1-4.

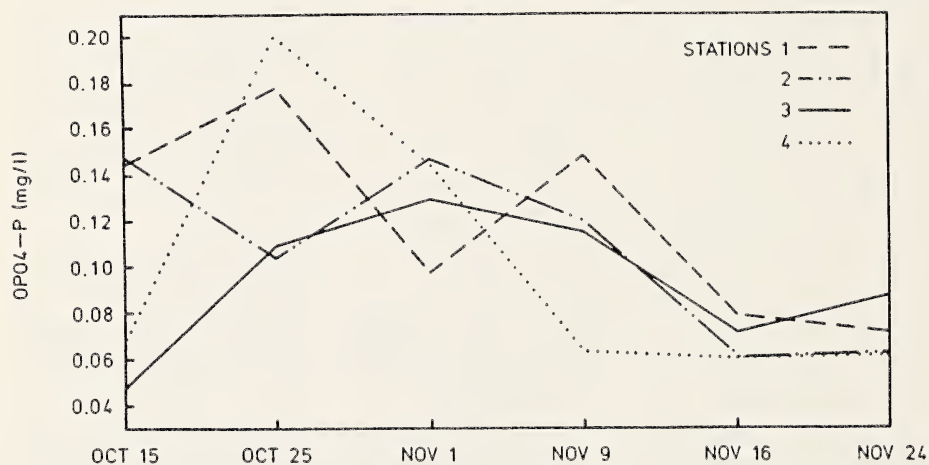


FIGURE 3. Orthophosphate ( $\text{OP}_4\text{-P}$ ) concentrations at stations 1-4.

chlorophyll *a* concentrations and a greater load of suspended and dissolved solids than stations 1 and 3. Salinity values were also consistently lower at these two stations, which compare to results obtained by Sinclair (1978), who observed the suspended load of non-living sediment is higher in low salinity waters.

Water temperature ranged from 8.3 to 22.3 °C, with the salinity between 18.1 and 20.9 ppt. Generally, salinity values were greater near the River mouth and lowest at station 4, the most upriver station. Surface and bottom salinities never varied by more than  $\pm 0.73$  ppt, with temperature differences not greater than 1.0 °C between surface and bottom waters. This indicated more of a holomictic state



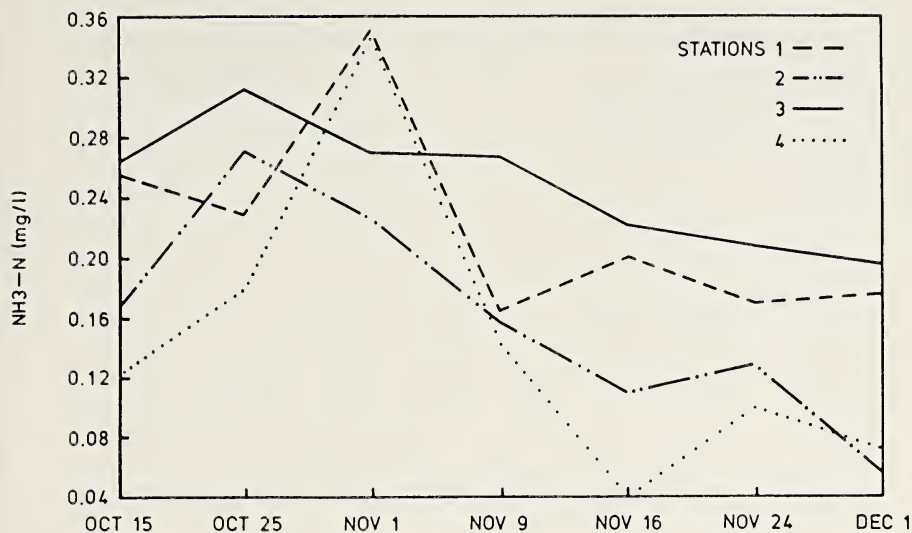


FIGURE 4. Ammonia ( $\text{NH}_3\text{-N}$ ) concentrations at stations 1-4.

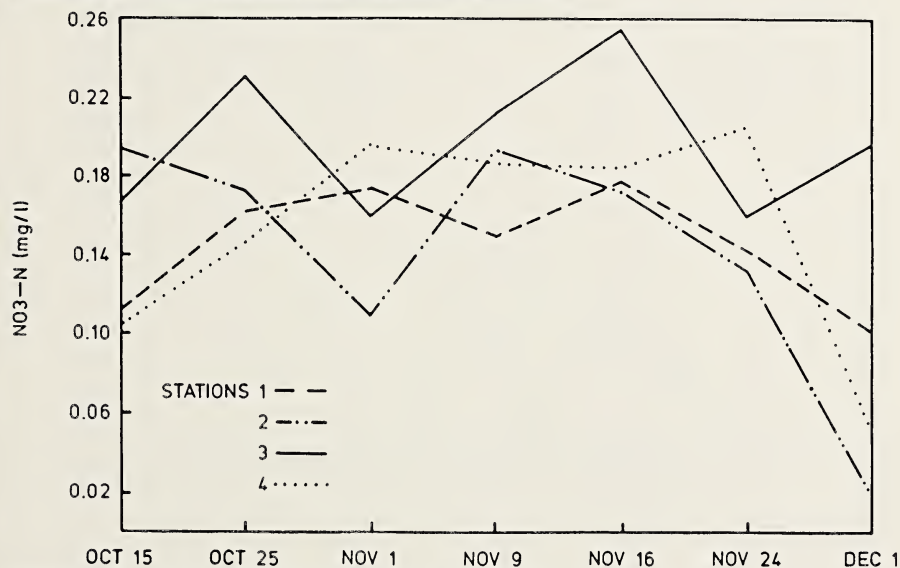


FIGURE 5. Nitrate ( $\text{NO}_3\text{-N}$ ) concentrations at stations 1-4.

for the water column at all stations during the study. An inverse relationship between water temperature and dissolved oxygen concentrations occurred, with oxygen values between 4.9 and 12.0 mg/l (Figure 2). The variations in orthophosphate ( $\text{OPO}_4\text{-P}$ ) concentrations of October decreasing into late November (Figure 3). The ammonia ( $\text{NH}_3\text{-N}$ ) levels were generally lower at station 4 and higher at station 3, with a trend of decreasing levels through November (Figure 4). Alden *et al.* (1986) reported surface ammonia concentrations in the near by Hampton Roads estuary for October through December 1984 (0.102 to 0.068 mg N/l) that were lower

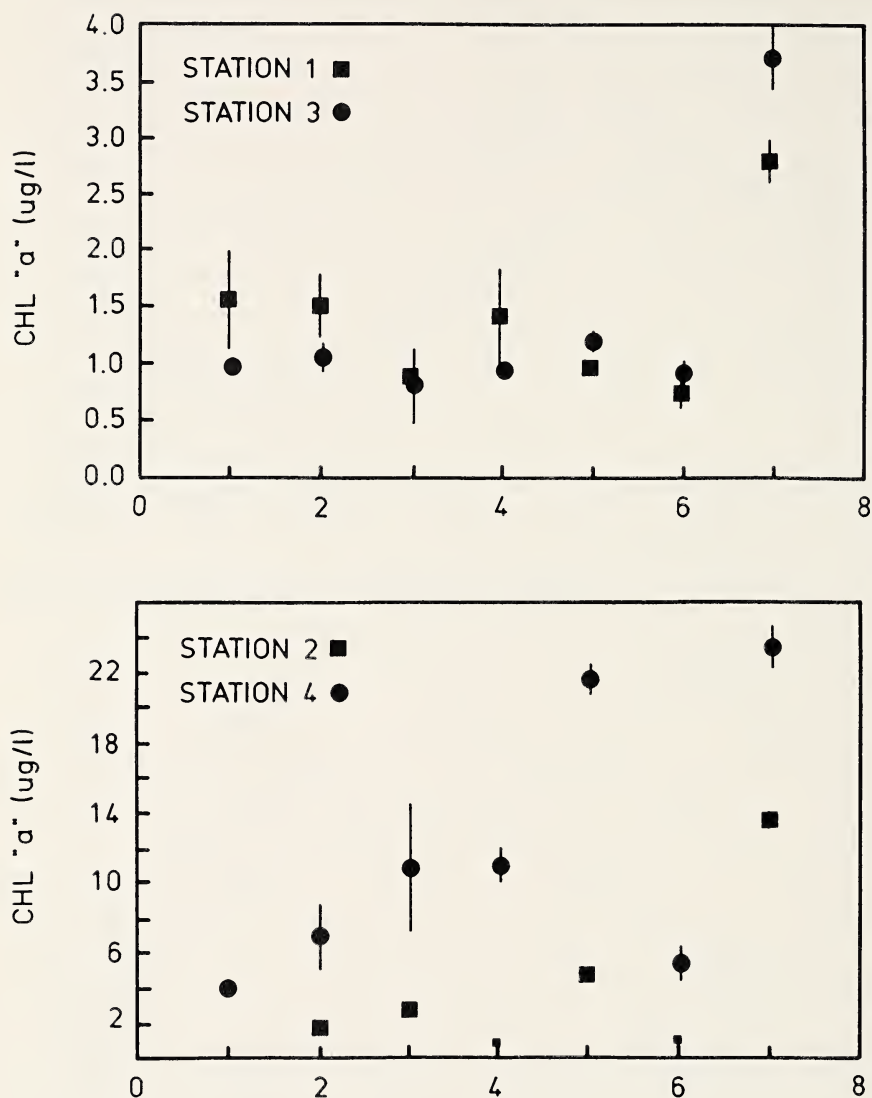


FIGURE 6. Weekly variation in morning chlorophyll *a* concentrations at stations 1-4

than the surface values found in this study for these same months (0.199 to 0.11 mg/l). McCarthy *et al.* (1977), 1984) have stressed that ammonia is significant because it is a preferred nitrogen source by estuarine phytoplankton. Nitrate ( $\text{NO}_3\text{-N}$ ) concentrations for the 4 stations ranged from 0.017 to 0.255 mg N/l (Figure 5). In a pattern similar to the other inorganic nutrients, nitrate concentrations were generally lower in December. Mean station and time of day surface nitrate concentrations in the River in October and November were higher (0.081 to 0.213 mg

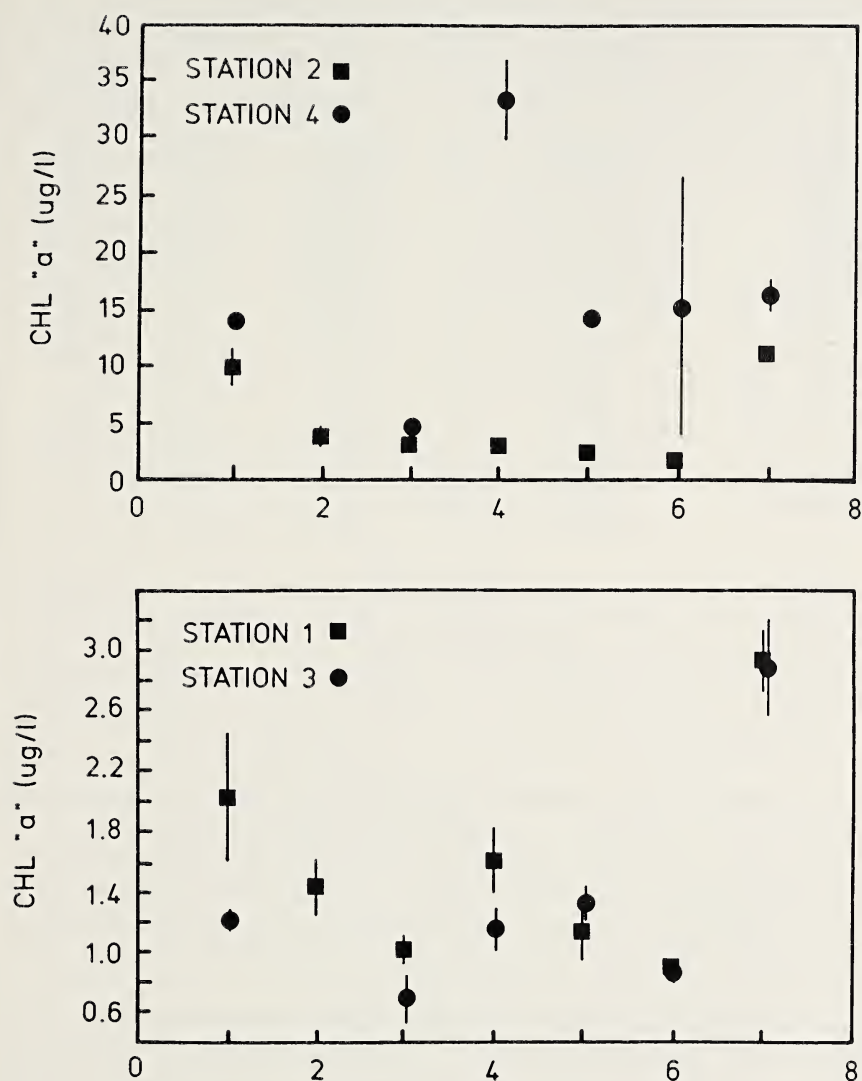


FIGURE 7. Weekly variation in afternoon chlorophyll *a* concentrations at stations 1-4.

N/l) than those previously reported by Alden *et al.* (1986) in Hampton Roads and by Adams *et al.* (1977) in the Elizabeth River.

Individual chlorophyll *a* concentrations ranged from 0.56 to 36.53  $\mu\text{g/l}$ . Figures 5-6 show the vertical mean chlorophyll *a* concentrations at the stations for morning and afternoon periods. Stations 1 and 3 have similar low biomass values, which ranged from 0.75 to 3.68  $\mu\text{g}$  chlorophyll *a*/l. Chlorophyll *a* concentrations at station 2 ranged between 0.93 and 13.60  $\mu\text{g/l}$ , with consistently high values at station 4, ranging from 3.98 to 33.46  $\mu\text{g/l}$ . These values correspond closely to the relative



TABLE 1. Three-way analysis of variance of chlorophyll *a* concentrations.

Sources of Variation	Sum of Squares	df	MS	F	F Prob
Main effects	10033.07	10	1003.31	315.85	0.001
weeks	1539.91	6	256.65	80.80	0.001
station	8267.47	3	2755.82	867.55	0.001
time	116.48	1	116.48	36.67	0.001
2-way interaction	3241.72	27	120.06	37.80	0.001
week * station	2158.52	18	119.92	37.75	0.001
week * time	833.87	6	138.98	43.75	0.001
station * time	156.53	3	52.17	16.43	0.001
3-way interaction	1609.83	16	100.62	31.67	0.001
week * station * time	1609.83	16	100.62	31.67	0.001
explained	14884.63	53	280.84	88.41	0.001
residual	857.67	270	3.17	----	----
Total	15742.30	323	48.74	----	----

phytoplankton counts taken during collections, with the highest concentrations consistently found at stations 2 and 4 (O'Reilly and Marshall, 1988).

Mean chlorophyll *a* and phaeophytin *a* concentrations were highest in December (9.63 and 4.72  $\mu\text{g/l}$ ) and lowest in November (3.36 and 1.18  $\mu\text{g/l}$ ). However, these phaeopigment concentrations may be overestimates. Suzuki and Fujita (1986) found chlorophyll *a* in *Skeletonema costatum* rather unstable, and that marked decomposition may occur during filtration and grinding. In the Elizabeth River, *Skeletonema costatum* was abundant in all samples throughout the study period (O'Reilly and Marshall, 1988). The acidification ratio (Yentsch and Menzel, 1963; Holm-Hansen *et al.*, 1965) ranged from 1.57 in November to 1.85 in December. Generally, temperature, salinity and ammonia concentrations were inversely related to chlorophyll *a* levels, while increased dissolved oxygen corresponded to higher chlorophyll *a* concentrations.

The results of analysis of variance (Table 1) indicated that all sources of variation, (e.g. the main effects and interactions) were highly significant. When these interactions are significant, the main effects cannot be interpreted in isolation (Sokal and Rohlf, 1981). However, the magnitude of the mean square for the spatial (station) effect, is at least an order of magnitude greater than other main effects or interactions. This indicates that mesoscale (6-14 km) phytoplankton biomass patchiness in the Elizabeth River was mainly due to spatial differences in chlorophyll *a* concentration, rather than variability in daily or weekly changes in the environment.

It is likely that some confounding effects are present due to short term temporal (daily) variation in the stations variance. This confounding may be due to the sampling program (Moll and Rohlf, 1981). The stations were sampled sequentially rather than simultaneously and always in the same order. Also, interpretation of fixed station short term temporal observations, from one to several sampling periods per week, is complicated by both higher frequency temporal variability of

TABLE 2. Results of a stepwise multiple regression analysis of chlorophyll *a* (chl *a*) concentration (dependent variable) and significant ( $p < .01$ ) independent variables. SBE = slack water before ebb current, SBF = slack water before flood current, E = ebb current, F = flood current.

Variables in the equation	Regression coefficient	Cumulative $R^2$	d.f.	Overall F
station 4	12.70	0.50	1,322	316.7
SBE * station 4	-9.42	0.57	2,321	215.6
SBF * station 4	8.45	0.61	3,320	172.4
station 2	3.13	0.65	4,319	149.5
Constant	1.44	---	---	---

TABLE 3. Regression models for predicted chlorophyll *a* concentration.

Category	Equation	Chl <i>a</i> ( $\mu\text{g/l}$ )
station1 & 3	chl <i>a</i> = 1.44	1.44
station 2	chl <i>a</i> = 1.44 + 3.13	4.57
station 4 * Flood & Ebb	chl <i>a</i> = 1.44 + 12.7	14.14
station 4 * SBE	chl <i>a</i> = 1.44 + 12.7 - 9.42	4.72
station 4 * SBF	chl <i>a</i> = 1.44 + 12.7 + 8.45	22.59

the semidiurnal tidal component and by possible advection of different water masses past the station (Sinclair *et al.*, 1981).

Table 2 summarizes the stepwise regression analysis. The square of the multiple correlation coefficient ( $R$ ) is the fraction of variance in chlorophyll *a* in the river which is explained by the regression. Station 4 accounted for 50% of the variance in chlorophyll *a* for the river. The interaction of slack-before-ebb current (high tide) with station 4 accounted for a further 7% of the variance. The inclusion of station 2 and the slack-before-flood current (low tide) with station 4 interaction accounted for an additional 8% of the variance in chlorophyll *a*. Other spatial, temporal or tidal variables (or interactions) made little further refinement to prediction of chlorophyll *a* (4% contribution to predicted chlorophyll *a*). Low water conditions in the Elizabeth River period accentuated the spatial biomass differences among these stations, while high water conditions effectively smoothed out differences (mainly station 4) in phytoplankton growth. The regression models for predicting chlorophyll *a* in the River are also listed in Table 3. Highest chlorophyll *a* concentration occurred at station 4 during slack-before-flood current. Much lower concentrations (4.72  $\mu\text{g/l}$ ) corresponded to slack-before-ebb at station 4 and were similar to predicted chlorophyll *a* at station 2 (4.57  $\mu\text{g/l}$ ). Stations 1 and 3 are low biomass areas with concentrations of 1.44  $\mu\text{g/l}$  chlorophyll *a*.

In summary, the phytoplankton chlorophyll *a* levels in the eastern and western branches (stations 2 and 4) of the Elizabeth River were greater than those found in the main stem (stations 1 and 3). The nutrient levels varied over the study period



generally decreasing from October to December, but were comparable to values previously found in nearby waters. Analysis of variance results indicated spatial differences between stations had a greater effect on chlorophyll *a* variations than the influence of the temporal differences of the physical-chemical variables measured. Other factors (*e.g.* light, temperature interaction) interacting with existing habitat conditions may stimulate or retard phytoplankton development in these habitats and account for station differences in the chlorophyll levels and productivity (Bruno *et al.*, 1980; Pennock, 1985; Malone, 1977). However, regression analysis indicated tidal state was important and accounted for up to 11% of the variance at station 4.

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#### LITERATURE CITED

- Adam, D.D., D.T. Walsh, C.E. Grosch and C.Y. Kuo. 1977. Investigative monitoring of sewage outfalls and contiguous waters of Hampton Roads, Elizabeth and James Rivers, and the lower Chesapeake Bay, Virginia, from June 1973 to May 1975. Tech. Report 22. Institute of Oceanography Old Dominion University, Norfolk, VA., 214 pp.
- Alden, R.W., A.J. Buitt and S. Sokolowski. 1986. Lower Chesapeake Bay monitoring program for 1984-1985. Technical Report submitted to the Virginia State Water Control Board. 87 pp.
- American Public Health Association. 1985. Standard Methods for the Examination of Water and Wastewater 16th edition. Washington, D.C. 1268 pp.
- Bruno, S.F., R.D. Staker and G.M. Sharma. 1980. Dynamics of phytoplankton productivity in the Peconic Bay estuary, Long Island, Estuarine and Coastal Mar. Sci. 10: 227-263.
- Cassie, R.M. 1963. Microdistribution of plankton. Oceanogr. Mar. Biol. Ann. Rev. 1: 223-252.
- Cerco, C.F. and A.Y. Kuo. 1981. Real-time water quality model of the Elizabeth River system. Special Report No. 215. Virginia Institute of Marine Science, Gloucester Point, VA. 105 pp.
- Environmental Protection Agency, 1979. Method for chemical analysis of water and waters. EPA-600/4-79-020/ United States Environmental Protection Agency, Cincinnati, OH: 365.3-1 to 365.3-4.
- Haffner, G.D., G.P. Harris and M.K. Jarai. 1980. Physical variability and phytoplankton communities III. Vertical structure in phytoplankton populations. Arch. Hydrobiol. 89(3): 363-381.
- Harris, G.P. 1980. Temporal and spatial scales in phytoplankton ecology. Mechanisms, methods, models, and management. Can. J. Fish. Aquat. Sci. 37: 877-900.



- Harris, G.P. 1984. Phytoplankton productivity and growth measurements: past, present and future. *J. Plankton Res.* 6(2): 219-237.
- Holm-Hansen, O., C.J. Lorenzen, R.W. Holmes and J.D.H. Strickland. 1965. Fluorometric determination of chlorophyll. *J. Cons. perm. Int. Explor. Mer.* 30(1): 3-15.
- Holmes, R.W. 1970. The secchi disk in turbid coastal waters. *Limnol. Oceanogr.* 15: 688-694.
- McCarthy, J.J., W.R. Taylor and M.E. Loftus. 1974. Significance of nano-plankton in the Chesapeake Bay Estuary and problems associated with the measurement of nanoplankton productivity. *Mar. Biol.* 24: 7-16.
- McCarthy, J.J., W. Kaplan and J.L. Nevins. 1984. Chesapeake Bay nutrient and plankton dynamics. 2. Sources and sinks of nitrite. *Limnol. Oceanogr.* 29(1): 84-98.
- Malone, T.C. 1977a. Environmental Regulation of phytoplankton productivity in the Lower Hudson estuary. *Estuarine and Coastal Mar. Sci.* 5: 157- 171.
- Margalef, R. 1967. Some concepts relative to the organization of plankton. *Oceanogr. Mar. Biol. Ann. rev.* 5: 267-289.
- Marshall, H.G. and R. Lacouture. 1986. Seasonal pattern of growth and composition of phytoplankton in the lower Chesapeake Bay and vicinity. *Estuarine, Coastal and Shelf Science.* 23: 115-130.
- Moll, R.A. and F.J. Rohlf. 1981. Analysis of temporal and spatial phyto-plankton variability in a Long Island Salt Marsh. *J. Exp. Mar. Biol. Ecol.* 51: 133-144.
- Neilson, B.J. 1975. A water quality study of the Elizabeth River. The Effects of the Army Base and Lamberts Point STP effluents. Special Report No. 75. Virginia Institute of Marine Science, Gloucester Point, VA. 133 pp.
- Neilson, B.J. and S.C. Sturm. 1978. Elizabeth River water quality. Special Report No. 134. Virginia Institute of Marine Science, Gloucester Point, VA. 45 pp.
- Okubo, A. 1974. Diffusion induced instability in model ecosystems: Another possible explanation of patchiness. *Chesapeake Bay Inst. Tech. Rep.* 86, John Hopkins Univ., Rep. 74-3.
- O'Reilly, R. and H. G. Marshall. 1988. Phytoplankton assemblages in the Elizabeth River, Virginia. *Castanea*. In press.
- Orion Scientific Instrument Corp. 1977. Nitrate and nitrite in water and seawater. Method No. 116-D233-01. Orion Scientific Instrument Corp. Hawthorne, N.J. 4 pp.
- Orion Scientific Instrument Corp. 1981. Ammonia in water and seawater. Method No. 116-D223-01. Orion Scientific Instrument Corp. Hawthorne, N.J. 2 pp.
- Pennock, J.R. 1985. Chlorophyll distributions in the Delaware estuary: regulation by light-limitation. *Estuarine, Coastal and Shelf Science.* 21, 711-725.
- Platt, T. 1972. Local phytoplankton abundance and turbulence. *Deep Sea Res.* 19: 183-187.
- Platt, T., L.M. Dickie and R.W. Trites. 1970. Spatial heterogeneity in a near-shore environment. *J. Fish. Bd. Res. Canada.* 27: 1453-1473.
- Powell, T.M., P.J. Richerson, T.M. Dillion, B.A. Agee, B.J. Dozier, D.A. Godden and L. O. Myrup. 1975. Spatial scales of current speed and phytoplankton biomass fluctuations in Lake Tahoe. *Science.* 189: 1088-1089.

- Rice, T.R. and R.L. Ferguson. 1975. Response to estuarine phytoplankton to environmental conditions. In: Vernbert, F.J., ed., *Physiological Ecology to Estuarine Organisms*, University of South Carolina Press, Columbia, SC, p. 1-43.
- Sinclair, M. 1978. Summer phytoplankton variability in the lower Saint Lawrence Estuary. *J. Fish. Res. Bd. Can.* 35: 1171-1185.
- Sinclair, M., D.V. Subba Rao and R. Coutre. 1981. Phytoplankton temporal distribution in Estuaries. *Oceanologica Acta* 4: 239-245.
- Sokal, R.R. and F.J. Rohlf. 1981. *Biometry*. W.H. Freeman and Company, San-Francisco. 859 pp.
- Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analysis. *Fish. Res. Bd. Canada Bull.* 167. 310 pp.
- Suzuki, R. and Y. Fujita. 1986. Chlorophyll decomposition in *Skeletonema costatum*: a problem in chlorophyll determination of water samples. *Mar. Ecol. Prog. Ser.* 28: 81-85.
- Turpin, D.H. and P.J. Harrison. 1979. Limiting nutrient patchiness and its role in phytoplankton ecology. *J. Exp. Msr. Biol. Ecol.* 39: 151-166.
- Yentsch, C.S. and D.W. Menzel. 1963. A method for the determination of phytoplankton chlorophyll and phaeophytin by fluorescence. *Deep Sea Res.* 10: 221-231.

## Design and Evaluation of a Simple Penetrometer for Measuring Leaf Toughness in Studies of Insect Herbivory

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### ABSTRACT

A penetrometer was designed to measure leaf toughness. The major components of the penetrometer were two pressure release valves and a pressure gauge from a sphygmomanometer, a plastic syringe, and a metal punching rod. The penetrometer was evaluated by measuring leaves of two different species and by statistically comparing these values to measurements made on the same leaves with a commonly used penetrometer first described by Feeney (1970). Both penetrometers gave similar measurements of leaf toughness for *Pelargonium* and *Schefflera* leaves but the King penetrometer allows more rapid measurement of leaves.

### INTRODUCTION

A number of morphological and chemical parameters of leaves are often measured in studies of insect herbivory. One of the most important morphological features influencing insect feeding is leaf texture. In trees and shrubs leaf toughness increases as the leaves mature. Feeney (1970) demonstrated that feeding on oak leaves by the winter moth caterpillar decreases as leaf toughness increases. Intraspecific as well as interspecific variation in leaf toughness have been correlated with herbivory (Waller 1982; Schultz and Baldwin 1982; Damman 1987; Howard 1988). Raupp (1985) found that tough leaves erode the cutting surface of beetle jaws more so than tender leaves.

A variety of devices have been used to measure leaf texture. Howard (1988) used a commercial penetrometer. Commercial penetrometers are expensive and are usually designed for testing of bituminous products and similar materials. Most depend on the free fall of a weighted needle. Cherrett (1968) designed a penetrometer in which increasing pressure was applied to a darning needle by means of an extension spring. The degree of extension required to produce penetration by the needle point was determined by the distance a knotted string moved along a ruler. It has not been widely used, perhaps because it does not ef-



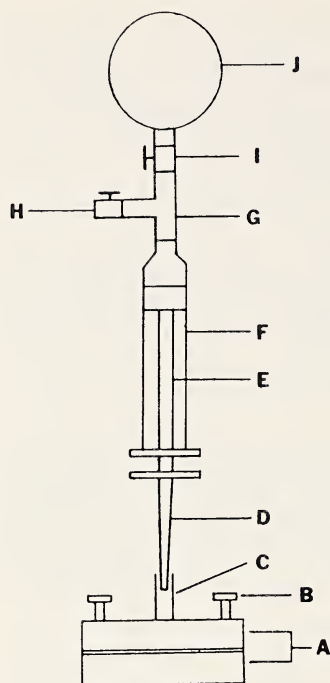


FIGURE 1. King penetrometer for estimating toughness of leaves. A) Wood block assembly; B) wing nut and bolt; C) plastic sleeve; D) brass punching rod; E) plunger of plastic syringe; F) plastic syringe; G) T-shaped plastic connector; H) and I) pressure release valves; J) aneroid pressure gauge.

fectively simulate the biting action of insect jaws and it is relatively complicated to construct. Earlier penetrometers (Williams 1954; Tanton 1962) measured leaf toughness by the weight of sand required to force an entomological pin through a leaf. Feeney (1970) modified these devices by using a 5 mm metal rod to punch out leaf discs. The action of the rod was to break the leaf tissue by a combination of shearing and tearing forces. The texture of leaves was estimated by the force (weight of sand) required to detach the leaf disc. The Feeney penetrometer has been widely used but the time required to measure a leaf is a major disadvantage.

The purpose of this study was to design a simple and inexpensive penetrometer which would measure leaf toughness as accurately as the Feeney (1970) device but which would do so more rapidly.

## MATERIALS AND METHODS

The King penetrometer and its components are diagrammed in Figure 1. A cylindrical hole was drilled through two smooth, hardwood blocks (15 x 10 cm, Figure 1, A). A leaf was placed between the two blocks which are held firmly together by two wing nuts and bolts (B). The upper block has a hole about 5 mm in diameter lined by a plastic sleeve (C) through which was passed a brass punching rod 2 mm in diameter (D) to puncture the leaf. These components are similar to the Feeney penetrometer but the punching rod is attached to the plunger (E) of an inverted 10 cc plastic hypodermic syringe (F). The upper end of the syringe (to which a hypodermic needle is normally attached) was connected to a T-shaped plastic tubing connector (G). Automatic pressure release valves (H and I) were

attached to each outlet. The upper valve (I) was fixed to an aneroid pressure gauge (J). This valve allows air into the gauge but not out and effectively converts it to a stop gauge. Valve H allows air into the system but not out. The system must be airtight. The pressure release valves and gauge are the type used in a sphygmomanometer but may be purchased separately. To use the King penetrometer, a leaf was placed between the wooden blocks. As force was applied to the leaf with the punching rod the hypodermic plunger was compressed and pressure increased in the system which registered on the pressure gauge. When the metal rod pushed completely through the leaf the pressure increase ceased and the needle of the pressure gauge stopped at that point. The pressure reading was the measure of leaf toughness. The penetrometer was readied for another measurement by depressing the pressure release valves (to return the gauge to zero and to release pressure from the system) and then pulling the plunger-metal rod assembly down to its starting point.

In practice the penetrometer may remain stationary and the wood block assembly attached to a small laboratory jack. Alternatively, the block may remain stationary and the penetrometer made mobile. For example, the power pod of a stereomicroscope may be removed and the penetrometer attached to the stand; especially if it has an extension arm. The focusing knob may be used to move the penetrometer up and down.

To estimate the effectiveness of the King penetrometer in measuring leaf toughness, the Feeney (1970) device was constructed and leaves of *Pelargonium* spp. and *Schefflera* spp. were measured with both penetrometers. Ten leaves of each species were measured with each penetrometer and each leaf was measured three times. Each leaf was measured with both devices but on opposite sides. Measurements were made at least 5 mm away from leaf margins and large veins were avoided. To make direct statistical comparisons of leaf toughness measurements between devices, pressure was converted to weight (sand). The King penetrometer was inverted and the metal rod was replaced with a plastic beaker. Increasing weights of sand were added to the beaker and the resulting pressure recorded. This was repeated three times. The resulting data were analyzed by regression. The regression equation ( $Y = -17.24 + 0.46X$ ;  $r = 0.997$ ) was used to convert leaf toughness measurements from the King penetrometer to weight measurements. Leaf toughness measurements of *Pelargonium* and *Schefflera* were then analyzed statistically by ANOVA and the means compared using a Tukey test.

## RESULTS AND DISCUSSION

Table 1 compares mean measurements of leaf toughness for *Pelargonium* and *Schefflera* using both penetrometers. There was no significant difference in mean measurements between devices for *Pelargonium* or *Schefflera*. Mean measurements of leaf toughness between *Pelargonium* and *Schefflera* were significantly different regardless of the device used. For both devices estimates of leaf toughness for *Schefflera* are about four times those for *Pelargonium*. Standard deviations for measurements with the King penetrometer were less than those with the Feeney penetrometer which may mean less variation due to the device itself.

TABLE 1. Comparison of mean measurements of leaf toughness for *Pelargonium* and *Schefflera* using two penetrometers. Statistical analysis by ANOVA and Tukey test.  $F = 193.95$ ;  $P < 0.0001$ ;  $DF = 3$  and 116; Tukey critical range = 41.46.

PENETROMETER	PLANT	MEAN	SD
FEENEY	<i>Pelargonium</i>	100.23	39.78
KING	<i>Pelargonium</i>	117.40	30.50
FEENEY	<i>Schefflera</i>	361.11	84.42
KING	<i>Schefflera</i>	396.12	74.36

Both of the penetrometers are inexpensive to manufacture (under \$50.00) and both gave similar estimates of leaf texture. In practice, however, the author was able to measure leaves 5 - 6 times more rapidly with the King penetrometer. It could be adapted for field use. Another possible advantage would be the modification of the penetrometer for electronic recording of data by replacement of the pressure gauge with a pressure transducer. Pressure transducers are available which connect to a PC board or to a computer interface especially designed for pressure/vacuum measurements.

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#### LITERATURE CITED

- Cherrett, J. M. 1968. A simple penetrometer for measuring leaf toughness in insect feeding studies. *J. Econ. Entomol.* 61:1736-1738.
- Dammon, H. 1987. Leaf quality and enemy avoidance by the larvae of a Pyralid moth. *Ecology* 68:88-97.
- Feeney, P. 1970. Seasonal changes in oak leaf tannins and nutrients as a cause of spring feeding by winter moth caterpillars. *Ecology* 51:565-581.
- Howard, J. J. 1988. Leafcutting ant diet selection: Relative influence on leaf chemistry and physical features. *Ecology* 69:250-260.
- Raupp, M. J. 1985. Effects of leaf toughness on mandibular wear of the leaf beetle, *Plagioderia versicolora*. *Ecol. Entomol.* 10:73-79.
- Schultz, J. C. And I. T. Baldwin. 1982. Oak leaf quality declines in response to defoliation by gypsy moth larvae. *Science* 217:149-150.
- Tanton, M. T. 1962. The effect of leaf "toughness" on the feeding of larvae of the mustard beetle *Phaedon cochleariae* Fab. *Entomol. Exp. Appl.* 5:74-78.



- Waller, D. A. 1982. Leaf-cutting ants and live oak: The role of leaf toughness in seasonal and intraspecific host choice. *Ent. Exp. Appl.* 32:146-150.
- Williams, L. H. 1954. The feeding habits and food preference of Acrididae and the factors which determine them. *Trans. Roy. Entomol. Society London* 105:423-454.

## NECROLOGY

**Edgar V. Russell, Jr.**  
(1912-1988)

Professor Edgar V. Russell, Jr. died in an automobile accident on August 25, 1988. He was professor emeritus of chemistry at Virginia Polytechnic Institute and State University, where he taught for over 36 years.

Professor Russell, known simply to his friends and associates as "Buck", was a well-rounded human being with many interests, but his primary concern was for quality education. He was a truly successful teacher, as witnessed not only by the respect of his colleagues, but by the continuing attention, visits, and correspondence of former students.

Buck joined the American chemical Society in 1938 and was an officer in the Virginia Blue Ridge Section of that Society, in which he was active until his death. Since 1946, he was a member of the Virginia Academy of Science, in which he worked diligently on the Science Talent Search Committee, and was elected a Fellow of the Virginia Academy of Sciences several years ago.

During World War II, Edgar (Buck) Russell served with the U.S. Army in Bremerton, Washington; Fort Sheridan, Illinois; and overseas in New Guinea, the Philippines, and Japan. He continued his military service in the active reserves until February, 1972, when he retired with the rank of Lt. Colonel.

Both before and after his retirement from Virginia Tech in 1973, he was extremely active in civic and church affairs. He was first sponsor of the Virginia Tech Rescue Squad, a member of Phi Eta Sigma, a member of the Golden Triangle of the Virginia Tech YMCA, and a past-officer and active member of the Blacksburg Lions club, and the American Legion. Buck was a member of the Blacksburg Baptist Church, as well as superintendent of the Sunday School, member of the Board of Deacons, church finance officer, and chairman of the Building and Grounds Committee.

Edgar V. Russell, Jr. is survived by his wife, Louise Hartness Russell, a son and daughter-in-law; a daughter and son-in-law; a sister, two grandchildren; and countless friends. "Buck" believed that we are placed on earth to make it a better place. Certainly, the world is a much better place for him having lived in it.



**Edgar V. Russell, Jr.**  
(1912-1988)



## Lead Poisoning in a Free Ranging Pekin Duck (*Anas platyrhynchos*) from Chesapeake, Virginia

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Lead poisoning as a mortality factor in waterfowl has been known for over 100 years (Sanderson and Bellrose, 1986). Hamburg and Babcock (1982) reported losses of 2 million ducks and geese to lead poisoning annually, with the yearly deposition of over 6,000 tons of lead shot. Recent reports of lead poisoning in waterfowl from Virginia are lacking. Wetmore (1919), reported lead poisoning in whistling swans (*Cynus columbians*) from Back Bay, Virginia, in January, 1915. The swans had in their gizzards from 22 to 45 lead pellets. In the mid-1950's C. P. Gilchrist, Jr. (1956) found whistling swans with large numbers of lead shot in their gizzards from Back Bay. Wetmore (1919) states that ducks and/or geese "...have been affected in various localities, in particular on Back Bay, Va.,...". Bellrose (1959), reports on work done by Shillinger and Cottam in 1936 reporting "...5 mallards from the Pamlico Sound area of Virginia...". Pamlico Sound is found in North Carolina, though connected to Back Bay, Virginia, through Currituck Sound the report may not be of Virginia birds.

On October 6, 1986 a pekin duck (*Anas platyrhynchos*) was picked up in the back yard of a domicile on Saint Julian's Creek, a tributary of the Elizabeth River in Chesapeake, Virginia. The bird was unable to move, with drooped wings, uncontrolled movement of head, difficulty breathing (gagging) and death occurred within an hour. Four mallards (*A. platyrhynchos*) and another pekin duck were found dead, but not collected, several days earlier. The collected specimen was forwarded to the U. S. Fish and Wildlife Service National Wildlife Health Center (NWHC) in Madison, Wisconsin where it was diagnosed (NWHC, Case # 6587) as having died from lead poisoning. Its gizzard contained four small lead shot and lead levels in the liver were 20.98 ppm wet weight. This was over twice as great as that reported by Roscoe (1986) who found wet weight lead concentrations of greater than 10 ppm were found in geese, swans and ducks having died of lead poisoning.

The area from where the duck was found normally is not hunted, however, several landowners shoot skeet on Saint Julian's Creek. The NWHC report places the shot size #8 from the gizzard of the duck to be consistent with skeet shooting loads.

### LITERATURE CITED

- Bellrose, F. C. 1959. Lead Poisoning as a Factor in Waterfowl Populations. Ill. Nat. Hist. Survey Bull. 27(3):235-288.  
Gilchrist, C. P., Jr. 1956. Back Bay Waterfowl Winter Resort. Va. Wildl. 17(12):16-17.

- Hamburg, D. D. and K. M. Babcock. 1982. Lead Poisoning and Lead/Steel Shot: Missouri Studies and a Historical Perspective. Missouri Dept. Conserv. Terrestrial Series #10. 23 pages.
- Roscoe, D. E. 1986. Diagnostic and Survey Techniques for Lead Poisoning in Waterfowl. in Feierabend, J. S. and A. B. Russell (eds). Lead Poisoning in Wild Waterfowl - A Workshop - Proc. Symp. held 3-4 March 1984, Wichita, Kansas. pages 27-32.
- Sanderson, G. C. and F. C. Bellrose. 1986. A Review of the Problem of Lead Poisoning in Waterfowl. Ill. Nat. Hist. Survey Spec. Publ. 4. 34 pages.
- Wetmore, A. 1919. Lead Poisoning in Waterfowl. U. S. Agric. Bull. 793. 12 pages.

## Albino Oyster Toadfish from the Choptank River, Maryland

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Albinism in wild, estuarine fishes is generally considered a rare occurrence; very few cases are reported (Dawson 1964, 1966, 1971). This paper reports an albino oyster toadfish (*Opsanus tau*) taken from a major tributary of Chesapeake Bay. It is the only known account of albinism in the family of toadfishes (Batrachoididae). On 9 October 1985, L. Wallace Harrison, A Chesapeake Bay fisherman, captured a single unpigmented female oyster toadfish from the Choptank River, a Maryland tributary of Chesapeake Bay. The specimen was taken by hook and line off Chlora Point, 8.24 km WSW of Trappe, Maryland at a depth of approximately 17 meters. The specimen (Fig. 1) was kept alive for six weeks in a static tank at the Horn Point Environmental Laboratories, University of Maryland. Upon death, the specimen was preserved in a 10% formalin solution, then transferred to a 44% isoproponal solution for permanent storage. The head, dorsum, and lateral areas of the albino were white with a yellowish tinge, and lacked mottling or reticulation; the abdominal region and numerous cirri of the head were immaculate white; the eyes were pink. All fins were white to yellowish-white. Background color of the head, dorsal and lateral regions of normally pigmented oyster toadfish (Fig. 2) vary from yellowish to greenish to brownish with mottling of brown and black. Ventral regions and flaps are yellowish. The soft dorsal and anal fins possess 5-9 irregular black bands; caudal, pectoral and pelvic fins have 5-7 dark cross bands (Martin and Drewry 1978). Fin ray and spine counts of the albino were first dorsal III, 0; second dorsal 0, 26; anal 21; left pectoral 19; left pelvic 2. These are similar to those of normal specimens (Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Martin and Drewry 1978). The ovaries of the mature albino female contained 222 eggs averaging 3.5 mm in diameter, which compares favorably with spawning females that usually possess fewer than 200 eggs (Martin and Drewry 1978). Total length was 216 mm (182 mm SL). Age and growth analysis as reported by Schwartz and Dutcher (1963) suggests this specimen was five to six years of age. The spawning season in the Chesapeake Bay region is from April to July or August when water temperatures reach and exceed 17 C. Water temperature in the Choptank River in late October and early November of 1985 was 10-12 C. The static tank in which the specimen was held at this temperature may have been sufficient time to induce the production of eggs.

### Literature Cited

- Bigelow, H. B. and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. U.S. Fish and Wildl. Serv. Fish. Bull. 53(74):1-577.



## NOTES

- Dawson, C. E. 1964. Bibliography of Anomalies of Fishes. Gulf Res. Rep. 1(6):310-399.
- Dawson, C. E. 1966. Bibliography of Anomalies of Fishes. Gulf Res. Rep. 2(2):169-176.
- Dawson, C. E. 1971. Bibliography of Anomalies of Fishes. Gulf Res. Rep. 3(2):215-239.
- Hildebrand, S. F. and W. C. Schroeder. 1928. Fishes of Chesapeake Bay. Bull. U.S. Bur. Fish. Vol. 43(part 1):1-388.
- Martin, D. F. and G. E. Drewry. 1978. Development of Fishes of the Mid-Atlantic Bight. Vol. 6. Stromateidae through Ogcocephalidae. pp. 341-351.
- Swartz, F. J. and B. W. Dutcher. 1963. Age, Growth and Food of the Oyster Toadfish near Solomons, Maryland. Trans. Amer. Fish. Soc. 92(2):170-173.



FIGURE 1 Albino oyster toadfish (*Opsanus tau*) from Choptank River, Maryland



FIGURE 2. Normally pigmented oyster toadfish (*Opsanus tau*) from Choptank River, Maryland.



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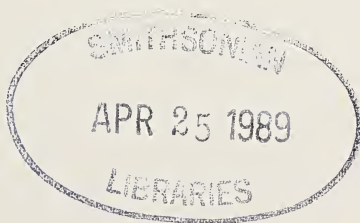
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## **X-Ray Diffraction Study of Indian Pot Sherds from Frederick County, Virginia: Clues Regarding Original Clays and Temperatures of Firing**

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### **ABSTRACT**

Mineralogical analyses were made of two pot sherds from a site at the Redbud Run marl deposit near Winchester, Virginia (age, from 500 B.C. to about 200 A.D.). X-ray diffraction studies of the original sherds, and portions heat-treated to 1100°C showed one pot was originally molded from kaolinite clay containing minor quartz and sodic plagioclase, while the second was originally molded from illite clay containing quartz and iron oxide. Apparently the original pots were fired at temperatures below 900°C, and evidence showed that one was fired to at least 500°C.

### **INTRODUCTION**

Because of the seemingly amorphous nature of the paste materials that make up prehistoric pottery, very little work has been done by archaeologists on the mineralogical composition of the materials. Usually they are merely described according to their physical appearance. Recent work at this laboratory (Mitchell and Hart, 1988), and elsewhere (Maggetti, 1982), has shown that x-ray diffraction analyses of the paste materials can be used to identify mineral phases that in turn indicate the compositions of the original clay materials used for manufacturing the ceramics and temperatures at which the ceramics were fired.

### **MATERIALS**

The pottery sherds used in this study were found by William F. Giannini in an abandoned pit of the Redbud Run marl deposit near Winchester, in Frederick County, Virginia. They were found beneath the soil layer near the top of marl, in association with a number of stones believed to have outlined a fire pit (Hubbard *et al.*, 1985). Because they are few in number, and because no tools were found with them, they probably represent a transient occupation. The outer surfaces of the pottery show evidence of having been malleated with net, a characteristic of pottery that was made during the first part of the Middle Woodland I phase (500 B.C. to 200, or slightly later, A.D.) (W. M. Gardner, personal communication, 1987; Gardner, 1988). William Boyer considered them to represent late Middle to early Late Woodland (about 750 A.D. to 1000 A.D.) Indians (Hubbard *et al.*, 1985).

TABLE 1. X-ray diffraction analysis of minerals in pot sherds heated at high temperatures.

PS 1				
1100°C	qtz	mull	Na-plagio (minor)	
1000°C	qtz	mull	Na-plagio (minor)	
900°C	qtz	mull (tr )	Na-plagio (minor)	
800°C	qtz	metakaol (tr )	Na-plagio (minor)	
400°C	qtz	metakaol (tr )	Na-plagio (minor)	
room temp	qtz	metakaol (tr )	Na-plagio (minor)	
PS 2				
1100°C	qtz	mull	cristo	hem
1000°C	qtz	mull (tr )	cristo (tr )	hem
900°C	qtz	hem		
800°C	qtz	illite (tr )	hem	
700°C	qtz	illite (tr )	hem (tr )	
600°C	qtz	illite	hem (?)	
500°C	qtz	illite		
400°C	qtz	illite (tr )		
room temp	qtz	illite (tr )		

Abbreviations: cristo (cristobalite), hem (hematite), Metakaol (metakaolinite), mull (mullite), Na-plagio (sodic-plagioclase), qtz (quartz), tr (trace).

For a detailed study, two clean sherds were selected: PS 1 and PS 2. PS 1 measures 1 cm thick and 3 by 4 cm across. The paste is black, and the smooth inner surface, as well as the rougher outer surface, are both light gray. These lighter surfaces represent leaching with some minor calcite deposition. Embedded in the sherd are numerous angular clasts (temper) of both gray, fine-grained limestone (to 5 mm) and minor vitreous quartz (to 2 mm). PS 2 measures 7 mm thick and is 2 by 2 cm across. The paste is brownish black, and the smooth, leached inner surface is light gray while the roughed leached outer surface is light brown. The leached surfaces contain traces of calcite. Embedded in the sherd are numerous angular to subrounded vitreous clear quartz clasts (temper), measuring to 3 mm across.

### BLEACHING BY HEAT-TREATMENT

Because the sherds are dark in color, supposedly from carbon, a study was made to see the effects of heat-treatment on the color. Small clean fragments of paste material from each of the two sherds were separated and then heated in a muffle furnace for one hour each in air at 100°C intervals. PS 1 retained its black color at successive temperatures through 400°C. At 500°C, it became a moderate light gray, and at 600°, the color was a pale orange, which persisted through 1100°C. PS 2 was the original brownish black through 400°C. However, at 500° it became moderate light brown, and at 600° and above the material was moderate red-brown. In both instances, therefore, the carbonaceous material began oxidizing at about 500°C and was completely gone after heating at 600°C. The significance of these results are somewhat ambiguous. If the carbonaceous material in the ceramic came from organic materials in the original clays from which the pots were made, it means the



firing of the original ceramic was not much above 400°C. However, it is more likely the black pigment was introduced later, after the pots were manufactured, from foods cooked in them, or from smoke. The black pigment shows that the cooking temperature was probably below 400°C.

### X-RAY DIFFRACTION STUDY

To prepare the materials for the x-ray powder diffraction study, fragments of untreated PS 1 and PS 2 were separately crushed. Under the microscope all larger rock and mineral (temper) fragments were removed, as well as all remnants of the outer leached zones that were contaminated with calcite. Finally the paste (matrix) materials were ground to a very fine powder using an agate mortar and pestle. Small samples of powdered PS 1 and PS 2 were placed in small high-temperature ceramic boats and heated in a muffle furnace (temperature control within  $\pm 20^\circ\text{C}$ ) for one hour each. The temperatures chosen were at 100°C intervals from 400°C through 1100°C. Each specimen was air quenched at room temperature and analyzed by x-ray diffraction. X-ray films were made in cameras of 11.46 cm diameter, using copper filtered radiation and exposure times of six hours. Although the film method takes considerably more time for each analysis than diffractometer, it has definite advantages when it comes to studying complicated mixtures. Relatively small samples are required. Contrasting grain sizes (for example, between clays, quartz and feldspars) and preferred orientations of some minerals are obvious on films. Also, the films show the entire diffraction patterns for a given mineral and are, therefore, easily compared with standard films of pure phases. The results of these analyses are shown in Table 1, where striking differences between the two sherds are evident.

The initial PS 1 sherd paste consists of a mixture of quartz, minor sodic plagioclase and a trace of metakaolinite (dehydroxylated kaolinite). Although kaolinite usually becomes nearly amorphous when heated in the range 500°C to 900°C, frequently well-crystallized kaolinite retains some degree of order when dehydrated by heating, and this is referred to as metakaolinite. In this study, x-ray reflections at 3.51 Å, and 4.51 Å, and 1.89 Å, obtained in earlier studies from analyses of samples of pure kaolinite prepared by heating at 800°C for 1 hour, were used to identify the presence of metakaolinite. Samples of the PS 1 sherd heated in hundred degree intervals from 400°C through 800°C yielded the same mineralogical composition as the original untreated sherd. At 900°C, the metakaolinite disappeared and a trace of mullite began to appear in its place. Samples heated to 1000°C and 1100°C contained mullite, quartz and minor sodic plagioclase (the latter two having survived from the original clay paste).

The presence of metakaolinite, and its transformation to mullite beginning at 900°C, showed that the original clay from which the sherd was made was kaolinite. The study also showed that the temperature at which the original ceramic was fired was not below 500°C, since no kaolinite, which can exist as high as 400°C, was present. On the other hand, the original firing temperature was below 900°C because metakaolinite, present in the original sherd, can not exist much higher than 800°C. The quartz and sodic plagioclase, which were present in all samples, were

present in the original kaolinite paste. These phases do not undergo changes within the temperature range of this study.

The original PS 2 sherd is composed of a mixture of quartz and illite clay. Although metakaolinite was not detected, one can not eliminate the possibility that some amorphous metakaolinite might be present. When samples of the PS 2 sherd were heated at hundred degree intervals from 400°C through 800°C, the quartz and illite phases persisted. However, with increasing temperatures, hematite was detected at about 600°C and was easily detected at all the higher temperatures. The presence of iron oxide (goethite or hematite) was suspected from the beginning because of the red-brown color of the material, but apparently at lower temperatures it was too fine-grained (amorphous) to be detected by x-ray diffraction. The illite phase decreased and finally disappeared at 900°C. In its place at 1000°C and 1100°C were mullite and cristobalite. Although there was no indication of metakaolinite in this PS 2 sherd, if it were present in an amorphous form, some of the mullite could have formed from it as well as from illite.

This study indicated that the original clay paste from which PS 2 was formed contained illite, quartz and extremely fine-grained iron oxide (goethite or hematite). The maximum temperature at which the original ceramic sherd was fired was 800°C. Its minimum temperature could not be established based on the fact that illite clay is not decomposed when fired over a wide range of temperatures.

### CONCLUSIONS

The two pot sherds, collected from the same site, were derived from different original clays. One was manufactured from kaolinite (containing minor quartz and sodic plagioclase), and the other was from illite (containing minor quartz and iron oxide). Neither original ceramic was fired as high as 900°C, and PS 1 was heated to at least 500°C or above, because no kaolinite unaffected by dehydroxylation was present. The loss of black or gray colors, due to carbonaceous materials in the sherds, was between 500°C and 600°C. On the basis of the temperatures indicated by the mineralogy of PS 1, the carbonaceous materials were probably not from carbonaceous contaminated original clay, but resulted from later cooking in the pots.

### LITERATURE CITED

- Gardner, W. M. 1988. Travertine/marl deposits and prehistoric archeological associations. Virginia Division of Mineral Resources. Manuscript in review.
- Hubbard, D. A., Jr., W. F. Giannini and M. M. Lorah. 1985. Travertine-marl deposits of the Valley and Ridge province of Virginia--a preliminary report. *Virginia Minerals* 31:1-8.
- Maggetti, M. 1982. Phase analysis and its significance for technology and origin. In *Archaeological Ceramics*. J. S. Olin and A. D. Franklin, Eds. Smithsonian Inst. Press. Washington, D. C. pps 121-133.
- Mitchell, R. S. and S. C. Hart. 1988. X-ray diffraction study of heated mineral mixtures related to ancient ceramic pastes: kaolinite or montmorillonite with calcite or dolomite. In *Archaeological Chemistry IV*. American Chemical Society. Washington, D. C. (in press).



## The Use of $R^2$ as a Measure of Goodness of Fit: An Overview

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### ABSTRACT

This is an expository note which points out the following: (1) A large value of  $R^2$  does not insure a good fit. (2) A low value of  $R^2$  may not result in a bad forecast. (3) A large value of  $R^2$  does not mean the model predicts well. (4)  $R^2$  cannot be 1 when repeated measurements exist. (5) There are simple artifices one can employ to raise the value of  $R^2$ . (6) Large value of  $R^2$  does not imply a causal relationship between the dependent and independent variables. (7) There are other measures of goodness of fit which may be more appropriate. The results are illustrated with citations of pertinent references.

The coefficient of multiple determination ( $R^2$ ) is the most popular measure used by researchers in assessing the success of regression and forecasting models. Note that  $R^2$  is the square of a multiple correlation coefficient, *i. e.*, the simple correlation between observed value ( $y$ ) and fitted value ( $\hat{y}$ ) and  $0 < R^2 < 1$ .

If we look at the standard analysis of variance representation of regression, it is usually computed as the ratio of the regression sum of squares to the total sum of squares. Although  $R^2$  can be interpreted as the "proportion of variance explained", it has several limitations and should be used cautiously (see Helland, 1987). The results of regression analysis are valid and have meaning only insofar as the assumptions concerning the residuals in the model are satisfied (Barrett, 1974).

A large value of  $R^2$  does not insure that the data have been fitted well. For example, the four data sets plotted in Figure 1 have the same set of basic summary statistics, including  $R^2$ . An analysis based exclusively on summary statistics would consequently be unable to detect the difference in data pattern and violations of assumptions, and would produce an incorrect analysis. A more detailed analysis is needed to ensure that the model adequately describes the data (Anscombe, 1977; Chatterjee and Price, 1977, pp. 7-8).

An  $R^2$  of 0 means that the model is not useful in explaining fluctuations, but it does not limit its ability to forecast levels. Thus  $R^2 = 0$  may not result in a completely bad forecast since the model may still account for the changes in levels.



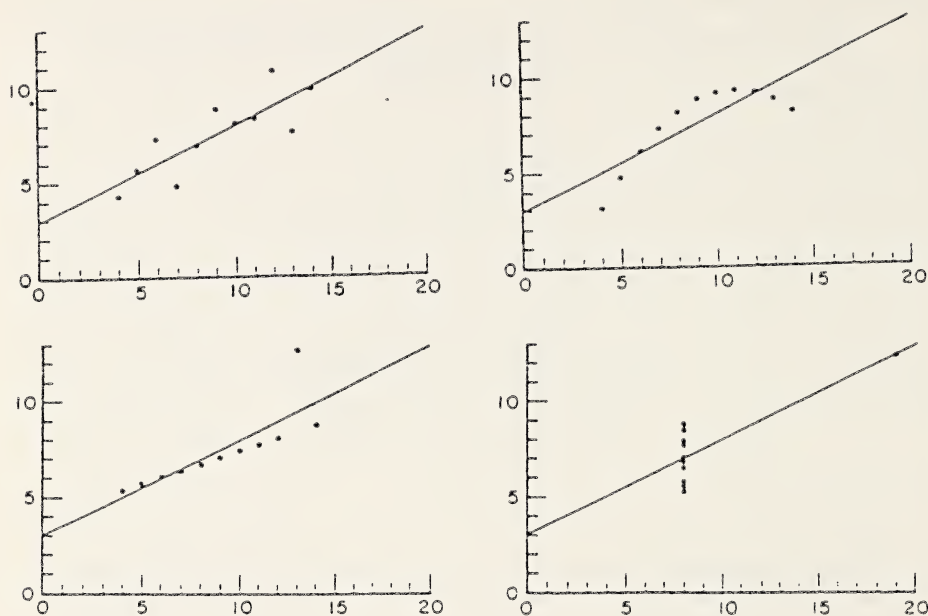


FIGURE 1. Plot of the data (X, Y) with the fitted line for four data sets. Source-Anscombe, 1977, p.324 (Reproduced by permission)

Similarly, as shown in Figure 2, an  $R^2$  of 1.0 does not represent a perfectly good forecast since  $R^2$  is a measure of the usefulness of the terms other than the intercept in the model (Draper and Smith, 1981, p. 91). Also  $R^2$  depends not only on fit of the data but also on the steepness of the regression surface, implying that  $R^2$  will be higher when changes are greater. Thus, in analyzing two different sets of data, it is possible that one regression may have a smaller residual sum of squares and yet, at the same time, have a smaller  $R^2$  because the particular regression surface is not as steep. That is, predictions based on a steep regression surface with a larger  $R^2$  might not result in higher precision (and could result in lower precision) than the predictions based on an equation with a surface not so steep with a smaller  $R^2$  (Barrett, 1974). This means that one can use  $R^2$  as a relative measure of goodness of fit, but not as an absolute measure. Thus, the predictive precision of the equation is of more practical value than  $R^2$ . In addition, several alternative statistics for computation of  $R^2$ , presented in the plethora of textbooks, are not generally equivalent except for linear models with an intercept term (Kvalseth, 1985; Willett and Singer, 1988).

In a recent paper, Draper (1984) shows that  $R^2$  is normally reduced when new replicate values of the dependent variable are introduced at existing values of a predictor. Moreover,  $R^2$  cannot attain the value of 1 when repeated or replicated measurements exist, no matter how well the model fit the data. This is because no model, however good, can explain the variation in the data due to pure error. For an algebraic proof of this result, see Draper and Smith (1981, pp. 547-548).

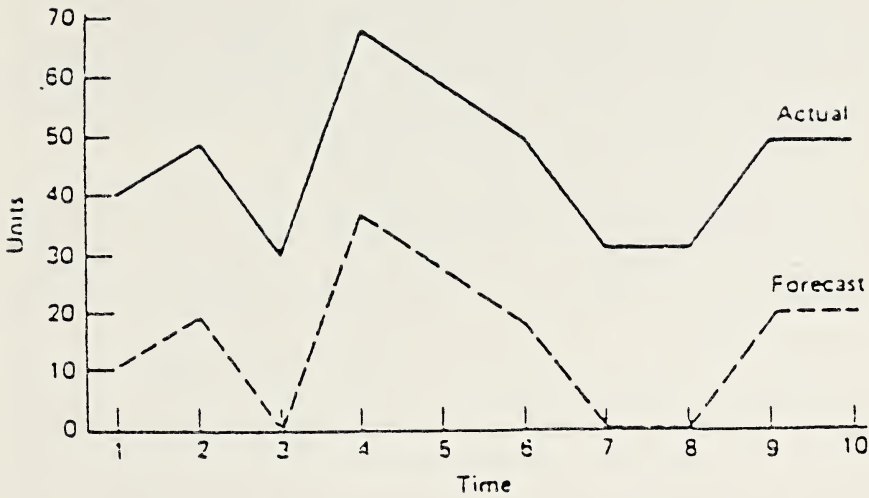


FIGURE 2. Perfect  $R^2$  does not imply a perfect forecast ( $R^2 = 1.0$  in this example). Source-Armstrong, 1977, p. 324. (Reproduced by permission)

Many analysts and researchers are overly impressed by a high  $R^2$ . However, there are simple artifices that one can employ to raise the value of  $R^2$ . For instance, if there is no pure error,  $R^2$  can be made equal to unity simply by including properly selected coefficients in the model, including the constant, equal to the number of data points. A model can then be determined to fit the data exactly. For example, given an observation at four different values of  $X$ , a cubic polynomial passed exactly through four points.

The researcher must insure that an improvement in  $R^2$  due to adding a new term in the model has some real meaning, and it is not simply because the number of parameters in the model is approaching the saturation point (the number of distinct  $X$ -points). This is especially crucial when there are repeated measurements. For example, if we have 100 observations which occur in five groups each with 20 repeats, we have essentially five distinct pieces of information, represented by five mean values, and 95 error degrees of freedom for pure error, 19 at each repeat point. Then a model with five parameters will provide a perfect fit to the five means and may yield a large value of  $R^2$ , if the experimental error is small compared with the spread of the five means (Draper and Smith, 1981, p. 91).

In the above case, the fact that 100 observations can be well predicted by a model with only five parameters should not cause any consternation since there are really only five distinct data points and not 100 as it may appear. When there are no exact repeats, but the points in the  $x$ -space at which  $y$  values are recorded are in proximity to each other, this type of situation can occur and yet will be concealed within the data. Plots of the data and of residuals will ordinarily be required before such clustering of data points can be discerned (Draper and Smith, 1981, p.91).

In as much as the regression sum of squares cannot decrease when new predictors are added to the equation, the increase in the number of predictors will usual-



ly increase  $R^2$  even when the regression coefficients are not statistically significant. In many instances,  $R^2$  can be artificially increased by doing the following:

- The outliers are discarded after examining the results of the regression analysis.
- The data are aggregated, especially when this significantly reduces sample size.
- The researcher experiments by trying different variables and many variables are included in the final equation.
- A step wise regression is used and all coefficients with t-statistics greater than 1 are included in the model (Haitovsky, 1969).

Doing the things listed above should result in  $R^2$  values of over 99% for time series data and about 90% for cross-sectional data. It is important not only to refrain from using such artificial means to increase  $R^2$  but also to be cognizant that others may use them.

A 'statistically significant' regression (as evidenced by significant F-value of significant  $R^2$ -value does not necessarily mean that the model is useful for predictive purposes. In order for the prediction to be useful, the range of predicted values obtained from the 'fitted model' should be considerably greater than the size of the 'random error'. Research work by J. M. Wetz and G. E. P. Box indicates that in order that a model equation be regarded as a satisfactory 'predictor' (in the sense that the range of response values predicted by the equation is substantial compared with the standard error of the response), the observed F-ratio should exceed about four times the corresponding critical value (Draper and Smith, 1981, pp. 92-93). For example, if  $n = 31$ ,  $p = 11$ ,  $\alpha = 0.05$ ,  $F(10, 20, 0.05) = 2.35$ ; and thus for the fitted regression model to be rated as adequate predictor, the observed F ratio should exceed 9.4.

To overcome some of the above difficulties, a modification of  $R^2$ , called the adjusted or corrected  $R^2$ , has been suggested and is defined by  $R^2_{adj} = 1 - (n-1)(1 - R^2)/(n - p)$  where  $n$  is the number of data points and  $p$  is the number of parameters (that is the number of regressors plus intercept) in the regression equation. Other measures of goodness of fit of a regression model to data, suggested in the literature include the  $C_p$  statistic, the  $J_p$  statistic, Prediction sum of squares (PRESSP), and Average Estimate of Variance (AEV). For a detailed discussion of these criteria, see Seber (1977, pp. 362-370).

More recently, Healy (1984) suggested an alternative to  $R^2$  as the following statistic:  $1 - (\text{residual mean square}/\text{total mean square})$ . The above statistic is not affected, on the average, by the addition of 'null' predictors and contrasts directly the variability of the values of the dependent variable about their predictions with and without the use of the predictor variables. A further alternative to  $R^2$  is the use of the quantity  $m$  proposed by Draper (1984). The choice of a given criterion will depend very much on how the chosen regression model will be used. It is recommended that several of the measures should always be calculated.

Finally, it is important to be cautious about the results obtained from a regression and forecasting model. A strong relationship or association (as evidenced by a high value of  $R^2$ ) does not necessarily prove or even imply that the independent variables are causally related to the dependent variable. In order to make such a causal inference, both additional methodology (Blalock, 1964, 1971) and experimentation, as in a carefully controlled clinical trial, are required.



## ACKNOWLEDGEMENTS

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## LITERATURE CITED

- Anscombe, F. J. 1977. Graphs in statistical analysis. *The American Statistician* 27:17-21.
- Armstrong, J. S. 1977. *Long-range Forecasting: From Crystal Ball to Computer*. John Wiley and Sons, Inc. New York. 612 pp.
- Barrett, J. P. 1974. The coefficient of determination - Some limitations. *The American Statistician* 28:19-20.
- Blalock, H. M., Jr. 1964. *Causal Models in the Social Sciences*. Aldine Publishing Company. Chicago. 515 pp.
- Chatterjee, S. and B. Price. 1977. *Regression Analysis by Examples*. John Wiley and Sons, Inc. New York. 228 pp.
- Draper, N. R. 1984. The Box-Wetzel criterion versus  $R^2$ . *Journal of Royal Statistical Society. Series A* 147:100-103.
- Draper, N. R. and H. Smith. 1981. *Applied Regression Analysis*. Second Edition. John Wiley and Sons, Inc. New York. 709 pp.
- Haitovsky, Y. 1969. A note on the maximization of  $R^2$ . *The American Statistician* 23:20-21.
- Healy, M. J. R. 1984. The use of  $R^2$  as a measure of goodness of fit. *Journal of Royal Statistical Society. Series A* 147:608-609.
- Helland, I. S. 1987. On the interpretation and use of  $R^2$  in regression analysis. *Biometrics* 43:61-69.
- Kvalseth, T. O. 1985. Cautionary note about  $R^2$ . *The American Statistician* 39:279-285.
- Seber, G. A. F. 1977. *Linear Regression Analysis*. John Wiley and Sons, Inc. New York. 465 pp.
- Willett, J. B. and J. D. Singer. 1988. Another cautionary note about  $R^2$ : Its use in weighted least squares regression analysis. *The American Statistician* 42:236-237.

# The Ericales of Virginia

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## INTRODUCTION

The families Clethraceae, Cyrillaceae, Empetraceae, Epacridaceae, Ericaceae, Monotropaceae and Pyrolaceae have been variously treated by taxonomists. According to Lawrence (1970), Engles and Diels placed the Clethraceae, Epacridaceae, Ericaceae and Pyrolaceae (including the Monotropaceae) in the Ericales and the Empetraceae and Cyrillaceae in the Sapindales. The relationship of the Empetraceae to the Ericales has been recently widely accepted and the relationship of the Cyrillaceae to the Ericales is becoming more apparent. The Clethraceae and the Cyrillaceae may be considered transitional between the Theales and Ericales. The Monotropaceae have been submerged in the Pyrolaceae and both of the former have been submerged in the Ericaceae. In this paper the Ericales will consist of the seven families previously named. All but two of these families are represented by taxa in Virginia. The Empetraceae occur in North America in the circumpolar regions, in mountain regions of the west and east, and the Atlantic Coastal Plain from South Carolina to Mississippi. The Epacridaceae are mainly Australian and not indigenous to the United States.

This paper is a contribution to the Flora of Virginia. The keys and descriptions have been compiled from Cronquist (1968), Fernald (1970), Gleason and Cronquist (1965, 1968), Lawrence (1970), Strasbaugh and Core (1978).

## Order Ericales

Plants with generally pentamerous flowers, petals basally connate or separate; stamens typically twice as many as the petals, in two whorls, those of the outer whorls opposite the petals and inserted at the edge of a usually hypogynous nectiferous disc; anthers usually with terminal pores and frequently with prominent appendages, pollen open in tetrads; placentation usually axile with numerous ovules in each locule. A large proportion of the species is obligately mycorrhizal. The genus *Rhododendron* and the genus *Vaccinium* have been recently covered (Roane, 1975; Uttal, 1987) and will not be treated here.

## Key to Ericales

- 1. Embryo normally developed, with 2 cotyledons;  
plants more or less woody, always chlorophyllous . . . . . 2

- 1'. Embryo very small and scarcely differentiated, without cotyledon; herbs or half-shrubs, often without chlorophyll . . . . . 6
2. Pollen grains born singly; stamens mostly twice as many as the petals, commonly opening by terminal pores . . . . . 3
- 2'. Pollen grains nearly always borne in tetrads (in some Epacridaceae only one grain of the tetrad matures) . . . . . 4
3. Ovules 1(-3) per locule; petals commonly joined at the base; seed without a seed coat; carpels 2-5 . . . . . 1. **Cyrtillaceae**
- 3'. Ovules numerous; petals free; seed with a seed coat; carpels 3 . . . . . 2. **Clethraceae**
4. Sepals and petals each 4-7; stamens as many as or twice as many as the corolla lobes; corolla mostly sympetalous; habit various mostly sympetalous; habit various . . . . . 5
- 4'. Stamens and sepals (petals) each 1-3, sepals separate; dwarf, often prostrate evergreen shrubs . . . . . 3. **Empetraceae**
5. Stamens mostly twice as many as the corolla lobes; leaves rarely palmately veined; anthers mostly opening by terminal pores, often appendiculate; widespread . 4. **Ericaceae**
- 5'. Stamens mostly as many as the corolla lobes; leaves mostly palmately veined; anthers opening by longitudinal slits, not appendaged; chiefly Australian . . . . . 5. **Epacridaceae**
6. Plants usually with green leaves; anthers opening by pores, pollen grains usually in tetrads; petals separate; placentation axile . . . . . 6. **Pyrolaceae**
- 6'. Plants without chlorophyll, leaves reduced to scales; anthers opening by longitudinal slits, pollen grains borne singly; petals separate or united; placentation axile or parietal . . . . . 7. **Monotropaceae**

### 1. **Cyrtillaceae.** Cyrtilla Family

Deciduous or evergreen shrubs or small trees; leaves alternate, entire, mostly coriaceous, estipulate, always chlorophyllous; flowers perfect, (4-)5-parted, actinomorphic, in racemes; sepals 5, basally connate, imbricate or rarely valvate, persistent and often enlarged in fruit; petals 5, distinct or basally connate, white or roseate, imbricated or convolute in bud, sessile or unguiculate; stamens 10 in 2 whorls of 5 each or the inner whorl lacking or reduced to staminodes, when 5 alternate with the petals, hypogynous; the filaments dilated and distinct; the anthers 2-celled, dehiscent longitudinally; pistil 1, ovary superior, 2-5-loculed and -carpelled, placentation axile, 1-4 ovules collaterally dispersed on each placenta, pendulous, anatropous; style 1, short or nearly obsolete; stigmas 2, linear-ovate; fruit a dehiscent capsule or leathery to fleshy drupaceous berry, often angled or winged; seed with small straight embryo, endosperm fleshy. Three genera, *Cyrtilla* and *Cliftonia*, monotypic, southeastern United States, and *Costaea*, three species in Cuba to Brazil and Columbia. Only *Cyrtilla racemosa* L. occurs in Virginia.

Cyrtilla Garden.

Plants, shrubs or small trees leaves oblanceolate to narrowly obovate, coriaceous, evergreen or nearly so; flowers regular, perfect, hypogynous, pen-



tamerous; sepals and petals imbricate; petals sessile; stamens alternate with petals; both stamens and petals attached under a disk; anthers somewhat sagittate, opening longitudinally; fruit indehiscent.

*Cyrtia racemosa* L. He huckleberry. Leatherwood. Ti-ti. Black ti-ti.

Shrub or small tree to 10 m., glabrous, leaves alternate, coriaceous, persistent, entire, oblanceolate, 5-10 cm, petiole 3-8 mm; clustered racemes borne just below the leafy branches of the season, spreading, slender, 6-10 cm, floriferous to base; flowers (4-) 5-parted, regular, perfect with white, oblanceolate acute petals slightly exceeding the stamens; fruit gray, round to ovoid, 2-3mm, excluding the persistent style. Swamps and wet woods on the Coastal Plain.

## 2. Clethraceae. White Alder Family

Shrubs or trees with stellate pubescence, always chlorophyllous; leaves alternate, simple, estipulate; flowers perfect, actinomorphic, white, very fragrant or spicily aromatic, in crowded terminal racemes or panicles; calyx 5-lobed, imbricate, persistent around fruit; corolla of separate petals, pentamerous, saucer-shaped, no disc present; stamens 10(12) in 2 whorls, distinct, hypogynous; filaments pubescent or glabrous; anthers 2-celled, extrorse, sagittate, inverted or inflexed in bud, dehiscing by apical pores, pollen in single grains; pistil 1, ovary superior, locules and carpels 3 (5 in *Schizocardia*), mostly 3-lobed, placentation axile, ovules numerous, anatropous, borne on placental intrusions; style 1; stigma 3-lobed; fruit a 3-valved, globose, loculicidal capsule whose septa separate from the central column; seeds 3-angled or flattened, some times winged. Two genera, *Clethra* 30 spp. of which 2 spp. in the Coastal Plain, 1 sp. in the mountains of eastern United States and *Schizocardia*, monotypic, native in British Honduras.

*Clethra* L. White alder. Sweet pepper-bush.

Shrubs or trees with alternate, serrate, deciduous leaves; flowers pentamerous, fragrant, white, in crowded terminal racemes; calyx persistent; sepals imbricated in the bud; petals obovate-oblong; anthers sagittate, erect in bud, becoming inverted, opening by terminal pore; pollen grains single, ovary 3-celled; style 3-lobed, slender; capsule 3-valved, globose, many-seeded, loculicidal, enclosed by calyx.

### Key to Species

1. Leaves 3.5-7 cm long, wedge-obovate, sharply serrate;  
racemes upright, usually paniced; bracts  
shorter than flower . . . . . 1. *C. alnifolia*
- 1'. Leaves 7-15 cm long, oval or oblong, pointed, finely serrate;  
racemes solitary, flexuous or drooping; bracts longer  
than the flowers . . . . . 2. *C. acuminata*

1. *Clethra alnifolia* L. Sweet pepper-bush. Shrub 1-3 m high; leaves 3.5-7 cm long, wedge-obovate, sharply serrate distally, entire toward base, prominently straight-veined, smooth, green both sides, tapering to a petiole 5-12 mm; racemes upright, usually in panicles, 5-20 cm, densely short-hairy as also the pedicels (2-5 mm) and calyx; petals oblong-obovate, 8 mm, white, rarely pink; bracts shorter than flowers; filaments glabrous. Swamps and moist woods near the coast.

2. *Clethra acuminata* Michx. Sweet pepper-bush. Shrub or small tree to 6 m; leaves oval, oblong, or elliptic, 5-15 cm long, half as wide, acuminate, thin, finely serrate over most of their length, base acute to rounded, sparsely villosulous beneath, on villose petioles 1-2.5 cm; racemes solitary, 8-15 cm, tomentose, as also the pedicels and calyx; petals 5-7 mm, pilose at base; bracts longer than the flowers, filaments hirsute; fruit densely villose. Rich woods in the mountains.

### 3. Empetraceae. Crowberry Family.

Low, shrubby, evergreen, heathlike shrubs with the narrow rigid foliage, aspect and compound pollen suggesting Heaths and the drupaceous fruit somewhat resembling that of *Arctostaphylos* but the divided or lacinate stigmas, *etc.*, of some Euphorbiaceae; leaves alternate, linear, deeply grooved beneath, estipulate; flowers usually perfect, axillary or congested in terminal heads, actinomorphic, small, apetalous; sepals 2-6, sometimes petaloid, bracteate or absent, imbricate, in 2 whorls, stamens 2-4, hypo gynous, distinct; the anthers 2-celled, dehiscing longitudinally; no disc present; pistil 1 (rudimentary in staminate flowers); ovary superior, 2-9 loculed and -carpelled; ovule solitary in each cell; style 1, short, variously lobed, fringed or divided, the stigmatic branches as many as the carpels; fruit a fleshy or dry berry containing 2 or more 1-seeded nutlets. By some considered an apetalous and degenerate ally of the Ericaceae but better kept in the Order Sapindales. Two genera, *Empetrum* and *Corema*. Neither occur in Virginia.

### 4. Ericaceae. Heath family.

Mainly shrubs, occasionally suffrutescent perennial herbs, trees or rarely trailing or scrambling vines to 20 m long; leaves alternate, some times opposite or whorled, chlorophyllous, simple, often coriaceous and persistent, estipulate. Flowers perfect, actinomorphic or slightly zygomorphic, solitary in axils or in axillary or terminal clusters, racemes or panicles; perianth biseriate, parts of each series usually more or less connate; calyx usually 4-7 lobed (sepals sometimes distant), usually persistent; corolla of 4-7 sometimes distinct but usually connate petals, often funnelform, campanulate or urceolate in form, convolute or imbricated; stamens as many as petals or corolla lobes, arising from the base of a disc, distinct, sometimes flattened or dilated and basally coherent to connate and sometimes forming a straight or S-curved tube; anthers 2-celled, thecae often saccate and basally bulbous, frequently appendaged, each thecae dehiscing introrsely by a terminal pore or chink or longitudinally; pollen grains in tetrads; pistil 1; ovary superior or inferior; locules and carpels 4-10, typically 5; ovules usually numerous; style 1, conical to filiform; stigma simple, fruit a capsule or berry (when capsular, the fruit may be baccate by its enclosure within the fleshy, persistent and sometimes adnate calyx). Widespread.

#### Key to The Ericaceae

1. Ovary superior, calyx free . . . . . 2
- 1'. Ovary inferior, calyx persistent at crown . . . . . 13
2. Flowers 4-merous, stamens 8, fruit 4-celled . . . . 1. *Menziesia*
- 2'. Flowers 5-merous, stamens 5 or 10, 5-celled . . . . . 3



3. Prostrate shrubs, fruit berry-like . . . . . 4
- 3'. Erect or ascending shrubs, fruit not berry-like . . . . . 5
4. Evergreen trailing shrub; leaves oval or obovate,  
cordate . . . . . 2. *Epigaea*
- 4'. Evergreen shrub with creeping, subterranean stems  
and upright simple branches; leaves elliptic or  
oblong, cuneate, having oval or obovate leaves  
at the top . . . . . 3. *Gaultheria*
- 5.. Fruit a drupe; prostrate shrub with rooting  
branchlets . . . . . 4. *Arctostaphylos*
- 5'. Fruit a capsule; upright shrubs or small trees . . . . . 6
- 6.. Capsule loculicidal, subglobose, globose or oblong-ovoid . . . . . 7
- 6'. Capsule septicidal, ovoid to oblong or depressed-globose . . . . . 12
7. Inflorescence lateral or terminal . . . . . 8
- 7'. Inflorescence terminal . . . . . 11
8. Capsule sutures thickened; calyx with 5 separate lobes . . . . . 10
- 8'. Capsule sutures not thickened; calyx with 5 imbricate lobes . . . . . 9
9. Flowers in lateral racemes . . . . . 5. *Leucothoe*
- 9'. Flowers solitary in axils of leaves . . . . . 6. *Chamaedaphne*
10. Inflorescences axillary on upper part of last year's  
branches; plant of Coastal Plain . . . . . 7. *Zenobia*
- 10'. Inflorescences axillary or terminal, on current year's  
branches; plants not limited to Coastal Plain . . . 8. *Lyonia*
11. Leaves deciduous; capsule oblong-ovoid;  
small tree . . . . . 9. *Oxydendrum*
- 11'. Leaves evergreen; capsule globose; shrub . . . . . 10. *Pieris*
12. Capsule ovoid to oblong, 0.5-1 cm or longer;  
inflorescence terminal; corolla campanulate  
to funnelform (Roane, 1975) . . . . . 11. *Rhododendron*
- 12'. Capsule ovoid to depressed-globose, less than  
1 cm wide; inflorescence terminal or lateral;  
corolla rotate or salverform . . . . . 12. *Kalmia*
13. Leaves usually resin-dotted; fruit a berry-like  
drupe with 10 one-seeded nutlets . . . . . 13. *Gaylussacia*
- 13'. Leaves not resin-dotted; fruit a many-seeded  
berry (Uttal, 1987) . . . . . 14. *Vaccinium*



1. *Menziesia* Sm.

Shrubs with alternate deciduous, short-petioled leaves and umbelliform or corymbiform clusters of flowers from terminal buds; flowers tetramerous; calyx saucer-shaped, shallowly lobed; corolla urceolate-campanulate, shallowly lobed; capsule short, thick-walled, septicidal.

*Menziesia pilosa* (Michx.) Pers. Minnie-bush. Alleghany *Menziesia*.

Shrub 1-2 m, with densely hairy twigs; petioles 2-4 mm; leaves thin, elliptic to oblong-obovate, 1.5-4 cm, pilose above, finely hairy beneath and with a few narrow, chaffy, lacerate or cleft scales on the midvein; flowers 2-several, on stipitate-glandular pedicels 1-3 cm; sepals glandular-ciliate; corolla greenish-red to yellow or nearly white, 8-10 mm, its erect lobes 1-2 mm; capsule minutely glandular, 6 mm. Mountain woods, Blue Ridge and west.

2. *Epigaea* L.

Prostrate, creeping evergreen shrub, often dioecious, bristly with rusty hairs; leaves leathery, alternate, evergreen, reticulated, rounded and heart shaped with slender petioles; flowers conspicuous, pentamerous, white to pink, fragrant, in short, crowded, terminal and axillary spikes; corolla salverform, tube thick, densely pubescent within, lobes long-ovate; capsule depressed-globose, at length 5-valved, many seeded.

*Epigaea repens* L. Trailing arbutus. Mayflower. Ground laurel.

Stems branched, 2-4 dm, hirsute; leaves ovate or oblong, 2-10 cm, entire, rounded or cordate at base, more or less pilose especially when young, with pubescent petioles half as long as blade; spikes 2-5 cm with ciliate bracts about equalling calyx; corolla tube 8-15 mm, lobes 6-8 mm. Sandy or rocky acid soil throughout the state.

3. *Gaultheria* L.

Erect to creeping shrubs with alternate evergreen leaves; flowers 4-5-merous, axillary, usually white, solitary in or just above the axils; pedicels with two bractlets; calyx campanulate to saucer-shaped, deeply divided; corolla tubular to campanulate, shallowly lobed; stamens included, 10, anthers oblong; capsule depressed-globular, thin-walled, enclosed when ripe by the calyx, which thickens and turns fleshy forming a dry or mealy berry-like structure.

*Gaultheria procumbens* L. Aromatic wintergreen. Wintergreen. Checkerberry. Teaberry. Mountaintea.

Leafy stems erect from a horizontal rhizome, 1-2 dm, with a few leaves crowded near the top; leaves obovate or oval, obscurely serrate, glabrous; petioles 2-5 mm; flowers pentamerous, on nodding pedicels 5-10 mm; calyx saucer-shaped; corolla barrel-shaped, 7-10 mm, the rounded lobes 1 mm; berry bright red, 7-10 mm. Berries and leaves have the spicy-aromatic flavor of sweet birch. Dry or moist woods in acid soil throughout the state.

4. *Arctostaphylos* Adans.

Freely branched shrubs with persistent alternate leaves and white to pink flowers in short, few-flowered, terminal racemes; flowers pentamerous, calyx

saucer-shaped, sepals imbricate, distinct to base; corolla ovoid, the 5 rounded lobes spreading or recurved; stamens 10, with pubescent filament much dilated below and much shorter than the corolla, with subglobose anthers opening by 2 terminal pores and bearing 2 deflexed terminal awns; fruit a fleshy or mealy drupe with 5 bony nutlets.

*Arctostaphylos uva-ursi* (L.) Spreng. Bearberry.

Prostrate shrub forming mats to 1 m or more wide; leaves entire, coriaceous, evergreen, oblanceolate to oblong-obovate, 1-3 cm, obtuse or rounded, tapering to base; sepals broadly ovate, 1.5 mm; corolla commonly white or tinged with pink, 4-6 mm; fruit bright red, dry or mealy, inedible, 6-10 mm, the 5 nutlets partly or usually wholly concrescent. Sandy or rocky soil of Tazewell and Page Counties.

5. *Leucothoe* D. Don. Fetterbush.

Evergreen shrubs with alternate petioled, serrulate leaves and white, scaly-bracted flowers in dense axillary or terminal spiked racemes, each pedicel 2-bracteolate at base, subtended and about equalled by an ovate bract; flowers pentamerous; calyx campanulate to saucer-shaped, persistent, the short lobes imbricate at base; corolla tubular, constricted at throat, the short, ovate lobes outwardly curved; capsule depressed-globose, more or less retuse, loculicidal.

Keys to Species

- 1. Inflorescence an axillary dense raceme;  
evergreen shrub . . . . . 2
- 1'. Inflorescence a terminal upright or spreading raceme;  
deciduous shrub . . . . . 3
- 2. Leaves long-acuminate, petioles 1-1.5 cm long;  
sepals ovate-oblong; corollas usually reddish  
in bud . . . . . 1. *L. fontanesianum*
- 2'. Leaves abruptly acuminate, petioles 0.5-1 cm long;  
sepals broadly ovate; oblong; corollas usually  
greenish in bud . . . . . 2. *L. axillaris*
- 3. Inflorescences nearly straight, capsules not lobed;  
sepal ovate-lanceolate . . . . . 3. *L. racemosa*
- 3'. Inflorescences recurved, capsules 5-lobed,  
sepals ovate . . . . . 4. *L. recurva*

1. *Leucothoe fontanesianum* (Steudel) Sleumer (L. editorum Fern. & Schub.)  
Shrub 1-2 m; leaves long-acuminate, commonly spinulose-serrulate; petioles 10-15 mm; racemes 4-10 cm; sepals lance-ovate, acute or subacute, 2 mm; corolla 5-7 mm. Along streams in the mountains of Bland, Lee and Scott Counties.

2. *Leucothoe axillaris* (Lam.) D. Don. Leucothoe.  
Shrub 1-2 m; leaves coriaceous, lanceolate or oblong to oblanceolate or elliptic, 8-15 cm, acute to abruptly short-acuminate, entire to spinulose-serrulate; petioles 5-10 mm; racemes sessile, dense, 2-4 (-5) cm; sepals broadly ovate, obtuse or rounded, 2 mm; corolla 6-8 mm. Wet woods of Coastal Plain; Virginia Beach,



Chesapeake, Suffolk Cities; Isle of Wight, Southampton, Surry and Sussex Counties.

3. *Leucothoe racemosa* (L.) Gray. Fetterbush.

Shrub to 4 m; leaves membranaceous and deciduous, oblong or oval-lanceolate serrulate; branches and racemes mostly erect; flowers very short-pedicel, in long one-sided racemes mostly terminating the branches; bracts deciduous; sepals ovate-lanceolate. Moist thickets of Carroll and Shenandoah Counties and most of the counties east of the Blue Ridge.

4. *Leucothoe recurva* (Buckley) Gray. Fetterbush. Recurved fetterbush.

Shrub to 4 m; leaves membranaceous and deciduous, lanceolate or ovate, taper-pointed, serrulate; branches and racemes recurved-spreading; flowers very short-pedicel, in long one-sided racemes mostly terminating the branches; bracts deciduous; sepals ovate. Dry hills, Alleghenies from Roanoke County west.

6. *Chamaedaphne* Moench. Leatherleaf. Cassandra.

Evergreen shrub with alternate leaves and stems, lower leaf surface brown-lepidote; axillary flowers numerous, in leafy raceme, pentamerous; calyx deeply parted, persistent, brown lepidote, closely subtended by 2 bractlets, the lobes imbricate; corolla nearly cylindric, slightly narrowed at the throat; stamens 10, included, with flat filaments and oblong anthers prolonged into 2 erect tubes as long as the body, opening by terminal pores; capsule depressed-globose, loculicidal. *Chamaedaphne calyculata* (L.) Moench.

Branching shrub to 1.5 m.; leaves oblong, elliptic or rarely obovate, 1.5-5 cm, minutely crenulate, petioles 1-3 mm; pedicels 2-5 mm, corolla white, 6-7 mm. In bogs often forming dense thickets, in mountains with Canadian flora. Should be looked for in boggy relict areas.

7. *Zenobia* D. Don

Shrubs with deciduous, veiny, crenate-serrate leaves; corolla campanulate with broad, short outcurved lobes less than 4 mm long, white or pink, ebractiolate, on long pedicels in umbelliform clusters from the nodes of a terminal axis, forming an elongate panicle; stamens 5-10, included, filaments slender, anthers lanceolate, attached by the back, pollen sacs united, with 2 erect, slender awns, opening by a terminal pore; ovary subglobose, style about equal to corolla tube, stigma truncate; capsule sub globose, 5-lobed, loculicidal, in fascicles.

*Zenobia pulverulenta* (Bartr.) Pollard

Rhizomatous shrub 1-2 m, with glabrous, often glaucous twigs; leaves glabrous or finely pubescent at first, broadly oval or elliptic, acute or obtuse, crenate, base cuneate to rounded, dull green above, usually glaucous beneath; inflorescences 1-4 dm; pedicels 1-3 cm; corolla 9-10 mm; fruit 4-7 mm thick. Wet woods and bogs on Coastal Plain.

8. *Lyonia* Nutt.

Deciduous or evergreen shrubs with alternate, entire or minutely serrulate leaves and flowers in umbelliform lateral clusters borne on leafless branches or in



the axils of leaves, forming a racemiform, leafy or naked panicle; flowers pentamerous; calyx saucer-shaped to campanulate, deeply divided, the lobes valvate; corolla globose to tubular or ovoid, the lobes short; capsule globose to truncate-ovoid, loculicidal, the sutures thickened and appearing as 5 rounded ribs.

#### Key to Species

1. Corolla urceolate; inflorescence subpaniculate;  
leaf margin serrulate . . . . . 1. *L. ligustrina*
- 1'. Corolla cylindric; inflorescence fasciculate;  
leaf margin entire . . . . . 2
2. Leaves coriaceous, persistent; corollas usually pink,  
swollen at base; capsules with apex at most  
slightly constricted . . . . . 2. *L. lucida*
- 2'. Leaves thin, deciduous; corollas usually white,  
not swollen at base; capsules with apex usually  
strongly constricted . . . . . 3. *L. mariana*

1. *Lyonia ligustrina* (L.) DC. Maleberry. Male-blueberry. Seedy buckberry. He-huckleberry.

Deciduous shrub to 4 m; leaves thin, mostly obovate or oblanceolate, 3-7 cm, acute or abruptly acuminate, very minutely serrulate; petioles 2-4 mm; umbelliform clusters usually only 2-6-flowered but very numerous, forming a panicle at the end of the branches of the previous year; sepals broadly triangular, 1-1.5 mm; corolla globose or broadly ovoid, 3-4 (-5) mm; capsule subglobose, 4 mm thick. Swamps and wet soil throughout the state.

2. *Lyonia lucida* (Lam.) K. Koch. (*L. nitida* (Bartr.) Fern. Fetterbush.

Evergreen shrub to 2 m; leaves coriaceous, glossy, elliptic to narrowly obovate, 3-7 cm, acute or abruptly acuminate, entire with a distinct vein parallel to and near the margin; petioles 2-5 mm; umbelliform flower clusters from the leaf axils; pedicels at anthesis 4-8 mm; sepals oblong, 3-5 mm, persistent; corolla 7-9 mm; capsule subglobose or depressed, 5 mm thick. Wet woods of Virginia Beach, Chesapeake and Suffolk Cities and Isle of Wight and Southampton Counties.

3. *Lyonia mariana* (L.) D. Don. Staggerbush.

Deciduous shrub to 2 m; leaves elliptic to oblong, 3-6 cm, commonly obtuse, entire, hairy on the veins beneath; petioles 2-4 mm; umbelliform flower clusters not subtended by leaves; pedicels 1-2 cm, bracteolate at the very base; sepals narrowly oblong, 4-10 mm, deciduous in winter, corolla 9-13 mm; capsule truncate, ovoid, 5 mm thick and usually longer. Moist sandy soil of Coastal Plain and Piedmont.

#### 9. *Oxydendrum* DC

Tree or tall shrub with alternate deciduous leaves and numerous white secund flowers in several elongate leafless racemes forming a terminal panicle; flowers pentamerous; calyx deeply parted, the lobes imbricate, spreading or reflexed at anthesis, persistent; corolla conic-ovoid, greatly constricted above, the tube canescent, the short lobes spreading or recurved; capsule oblong-ovoid, 5-angled, loculicidal.

*Oxydendrum arboreum* (L.) DC. Sourwood. Sorrel-tree.

Tree to 20 m, beginning to flower at 2-3 m; leaves oblong, elliptic, or lance-ovate, 10-15 cm, acuminate, entire or serrulate; petioles 1-1.5 cm; racemes 4-7 at end of each branch, widely spreading, 5-15 cm; pedicels 3-8 mm, minutely bracteolate near the middle; corolla 6-7 mm; capsule 5-7 mm. Woods throughout the state.

#### 10. *Pieris* D. Don

Shrubs with alternate evergreen leaves and white flowers in terminal panicles; flowers pentamerous; calyx persistent, campanulate, the sepals coriaceous, valvate at base; corolla ovoid, much constricted above, 5-saccate at base alternately with the sepals, sharply 5-angled in bud; capsule globose, not retuse, not thickened at the sutures.

*Pieris floribunda* (Pursh) Benth. & Hook. (*Andromeda floribunda* Pursh) Mountain fetterbush.

Shrub to 2 m; leaves coriaceous, lanceolate to lance-elliptic or oblong, 3-7 cm, entire or minutely serrulate, ciliate, acuminate; petioles 5-10 cm; flowers solitary at the nodes of an elongate, bracteate raceme, the short pedicels 2-bracteolate near the middle, the few to several racemes each 3-6 cm, forming a terminal panicle, sepals triangular, 2-3 mm; corollas 5-6 mm, capsules 5-6 mm. Mountain woods from Pittsylvania County north and west.

#### 11. *Rhododendron* L. (See Roane, 1975.)

#### 12. *Kalmia* L. Laurel.

Evergreen mostly smooth shrubs, with alternate or opposite entire coriaceous leaves, naked buds and conspicuous flowers; flowers pentamerous; calyx deeply lobed; corolla shallowly lobed, 10-saccate about halfway from base to margin; stamens 10, the short anthers at first fitting into the corolla sacs, the filaments later springing inward; capsule 5-celled, ovoid to depressed-globose, septicidal.

#### Key to Species

1. Inflorescence terminal; corolla 2-2.5 cm wide;  
capsule 6-8 mm wide; leaves 3-5 cm long . . . . . 1. *K. latifolia*
- 1'. Inflorescence lateral; corolla 6-12 mm wide;  
capsule 3-5 mm wide leaves 3-5 cm long . . . . . 2. *K. angustifolia*

#### 1. *Kalmia latifolia* L. Mountain laurel. Calico bush. Spoon-wood.

Shrub or small-tree 2-3 (-10)m, often forming dense thickets; leaves all or mostly alternate, bright green on both sides, coriaceous, elliptic or lanceolate, 5-10 cm, usually acute at both ends, glabrous, with petioles 1-3 cm long; flowers in terminal corymbs, on pedicels 1-4 cm; sepals lance-oblong, 3 mm, not imbricate; corolla white to rose with purple markings, 2-2.5 cm wide; fruit depressed-globose, 6-8 mm wide. Woods, mainly in sandy or rocky acid soils throughout the state.

#### 2. *Kalmia angustifolia* L. Sheep laurel. Lambkill. Wicky.

Branching shrub to 1 m; leaves firm, commonly opposite or in threes, pale and glabrate beneath, bright green above, elliptic or oblong, 3-5 cm, a fourth or half as wide, short-petioled; flowers several or many in short-peduncled, umbelliform or



corymbiform racemes from the axils of last year's leaves on minutely puberulent or glandular pedicels to 2 cm; corolla 6-12 mm, reddish-purple to deep pink; fruit depressed-globose, 3-5 mm thick. Mostly in acid soils, hillsides, pastures and bogs in Accomack, Carolina, Carroll, Grayson, Isle of Wight, Southampton Counties and Cities of Suffolk, Virginia Beach and Chesapeake.

### 13. *Gaylussacia* HBK Huckleberry

Freely branched shrubs, often colonial, commonly conspicuously glandular, with small, alternate, deciduous or evergreen leaves; flowers pentamerous, white or pink-tinged, in lateral bracteate racemes; hypanthium short, obconic; calyx 5-lobed, persistent; corolla tubular, obconic, scarcely if at all constricted above, the short lobes erect or outcurved; stamens 10, included; fruit 10-celled, a fleshy drupe with 10 seed-like nutlets, edible but of poor quality.

#### Key to Species

1. Leaves serrulate, coriaceous, evergreen,  
not resin-dotted . . . . . 1. *G. brachycera*
- 1'. Leaves entire, deciduous, resin-dotted  
on one or both sides . . . . . 2
2. Sepals, pedicels, bracts and leaves with  
sessile glands, not pubescent . . . . . 3
- 2'. Sepals, pedicels, bracts stipitate-glandular,  
densely pubescent; leaves stipitate-glandular . . . 2. *G. dumosa*
3. Leaves glandular on lower side;  
racemes exceeding leaves . . . . . 3. *G. frondosa*
- 3'. Leaves glandular on both sides;  
racemes short than leaves . . . . . 4. *G. baccata*

#### 1. *Gaylussacia brachycera* (Michx.) Gray. Box huckleberry

Plants not glandular, with stems 2-4 dm, bearing a conspicuous ridge below the base of each leaf and colonial by long woody rhizomes; leaves coriaceous, evergreen, elliptic, 12-22 mm, finely serrulate, glabrous; racemes few-flowered, subsessile, shorter than the subtending leaves; pedicels very short; corolla cylindric-campanulate, 5 mm; fruit dark blue, edible. Wooded hillsides, chiefly in the mountains of Bath, Bland, Carroll, Craig and Montgomery Counties.

#### 2. *Gaylussacia dumosa* (Andr.) T&G. Dwarf huckleberry.

Plants colonial by long woody rhizomes, sending up leafy branches 2-5 dm; leaves deciduous, oblanceolate to obovate, 2-4 cm, entire, inconspicuously stipitate-glandular; racemes rather dense; bracts oval or oblong, foliaceous, persistent, 5-12 mm; pedicels, hypanthium, and calyx pubescent and copiously stipitate-glandular; sepals glandular-ciliate, corolla 5-9 mm; fruit black, hairy, 5-9 mm. Usually in wet sandy soil or bogs, on or near the Coastal Plain, in Augusta, Brunswick, Charlotte, Dinwiddie, Isle of Wight, Lunenburg, Mecklenburg, Page, Prince George, Southampton, Surry Counties and City of Suffolk.

#### 3. *Gaylussacia frondosa* (L.) T&G. Dangleberry. Blue Tangle.

Plants widely branched, to 2 m; leaves deciduous, elliptic or oblong to oblong-obovate, 3-6 cm, with minute, sessile, resinous glands beneath; racemes slender,



loose, usually surpassing leaves; bracts linear-oblong to elliptic, deciduous; pedicels usually much longer than the flowers; pubescence of the inflorescence and flowers sparse or none, the glands sessile, if persistent, and the sepals not ciliate; corolla 3-4.5 mm, its tube two-thirds as thick; fruit dark blue, glaucous, 7-8 mm. Moist woods, thickets, and clearings in acid soil of Piedmont, Coastal Plain and Augusta, Bath, Craig, Giles, Page, Scott and Tazewell Counties in the mountains.

4. *Gaylussacia baccata* (Wang.) K. Koch. Black huckleberry.

Much branched shrub to 1 m; leaves deciduous, elliptic to oblong or oblanceolate, 2-5 cm, entire, resinous-glandular on both sides; racemes short, rarely surpassing leaves; pedicels commonly shorter than flowers; bracts oblong to linear, deciduous; pubescence of inflorescence and calyx usually copious, the glands sessile and commonly numerous, the sepals not ciliate; corolla 4-6 mm, its tube half as thick; fruit black, without bloom, pleasant, 6-8 mm. Dry, sandy or rocky soil, woods and thickets throughout the state.

#### 14. *Vaccinium* L. (See Uttal, 1988.)

### 5. Epacridaceae. Epacris Family

Shrubs or small trees, leaves alternate, chlorophyllous, often crowded, simple, small and heathlike, usually stiff, estipulate; flowers dioecious, rarely mostly monoecious, actinomorphic, calyx 4-7 lobed, persistent; bracteate; corolla mostly sympetalous, 4-7 lobed, valvate or imbricate; stamens usually 5 (4), epipetalous or hypogenous, alternating with the corolla lobes, sometimes with alternating staminodes represented by clusters of hairs or glands, anthers 1-celled at anthesis, dehiscing longitudinally, pollen grains borne in tetrads although only 1 grain of the tetrad may mature; pistil 1, ovary superior, often surrounded basally by an hypogenous glandular disc, locules 1-10, carpels 4-5, placentation typically axile, ovules solitary to many in each locule; style 1; stigma capitate; fruit a 5-valved capsule or drupe with a 1-5 seeded stone. Mainly Australian although species of *Epacris*, *Cyathodes* and *Leucopogon* are cultivated domestically in the warmer areas of the United States. None are native to Virginia.

### 6. Pyrolaceae. Pyrola Family

Perennial herbs or half-shrubs with creeping scaly rootstocks; leaves chlorophyllous, alternate, nearly opposite or in false whorls, simple, persistent or deciduous, mostly coriaceous and toothed, estipulate; flowers perfect, actinomorphic or nearly so, bracteate; calyx of 5 distinct or briefly connate persistent sepals; corolla waxy, petals 4-5, distinct, hypogynous; disc present or absent; stamens 8-10, distinct, hypogynous, with filaments often dilated basally, anthers dorsifixed, 2-celled, produced into a tubelike apex with a terminal pore, often reflexed after anthesis so that the pore becomes distal, pollen in tetrads; pistil 1, ovary superior, 5-lobed, locules and carpels 5, placentation typically axile with the placenta intruded into each locule and bifurcate, ovules numerous in each locule, anatropous, style and stigma 1; capsule loculicidal. The family is represented in North America by the monotypic genera *Moneses* and *Ramischia* and the genera *Chimaphila* and *Pyrola*. The latter two genera occur in Virginia.

## Key to Genera

1. Style very short; stigma broad, filling summit of ovary; leaves on the stem . . . . . 1. *Chimaphila*
- 1'. Style elongate, conspicuous; leaves all basal . . . . . 2. *Pyrola*

1. *Chimaphila* Pursh. Pipsissewa

Low, perennial, evergreen half-shrubs from a creeping rhizome, with thickish denticulate leaves in a subverticillate cluster; inflorescence a terminal, long-peduncled, few-flowered umbel or corymb of white or pink flowers with 5 distinct spreading petals; stamens 10 with filaments much dilated below and slender above and plump anthers attached at the middle, connate below the filament, separate and tapering above, opening by wide terminal pore; fruit a capsule splitting from the apex downward.

## Key to Species

1. Leaves oblanceolate, not marked with white, tapering to the base . . . . . 1. *C. umbellata*
- 1'. Leaves lanceolate, striped with white, obtuse or rounded at base . . . . . 2. *C. maculata*

1. *Chimaphila umbellata* (L.) Bart. Prince's pine. Pipsissewa.

Stem spreading, 1-3 dm high; leaves wedge-lanceolate, 3-6 cm, sharply serrate, not spotted, acute or mucronate, tapering to a short petiole; flowers 4-8, corymbose or subumbellate, 10-15 mm wide; dilated part of filaments ciliolate; fruit a capsule. Dry woods, especially in sandy soil throughout the state except the southwestern part of the state.

2. *Chimaphila maculata* (L.) Pursh. Spotted wintergreen. Striped wintergreen. Stem 1-2.5 dm high; leaves lanceolate or ovate-lanceolate 2-7 cm, obtuse at base, remotely and sharply toothed, short-petioled, upper surface variegated with white; flowers 1-5, umbellate, 12-18 mm wide; dilated part of filaments villose; fruit a capsule. Dry woods, especially in sandy soil throughout the state.

2. *Pyrola* L. Shinleaf. Wintergreen.

Rhizomatous smooth perennial, the few broad, petiolate leaves nearly basal; flowers in an erect, terminal, long-peduncled raceme; flowers with regular perianth, polypetalous, pentamerous, fruit a capsule.

## Key to Species

1. Leaf blade longer than petiole . . . . . 2
- 1'. Leaf blade as short as or shorter than the petiole . . . . . 3
2. Inflorescence secund; leaves 1.5 - 4 cm., elliptic to broadly ovate or subrotund . . . . . *P. secunda*
- 2'. Inflorescence not secund; leaves 3-7 cm., broadly elliptic or oblong . . . . . 2. *P. elliptica*
3. Scape with 8 or fewer flowers, naked or with a single small bract; leaves 1-3 cm; plant small, delicate . . . 3. *P. chlorantha*



- 3'. Scape with 8 or more flowers, bracted;  
leaves 2.5 - 7 cm; plant robust . . . . . 4. *P. rotundifolia*

1. *Pyrola secunda* L. One-sided Pyrola.

Leaves elliptic to broadly ovate or subrotund, 1.5-4 cm, obtuse or rounded entire to crenate-serrate, obtuse or rounded at base, often separated by conspicuous internodes; scape 1-2 dm; raceme crowded, secund; sepals semicircular to ovate, 0.5-1 mm; petals white or greenish, 5 mm; differs from other species in having 10-lobed hypogynous disk, basally bituberculate petals and simple pollen grains (not in tetrads). Moist woods and mossy bogs of Fairfax, Fauquier and New Kent Counties.

2. *Pyrola elliptica* Nutt. Shinleaf. Wild lily-of-the-valley.

Leaves commonly longer than petiole, broadly elliptic or oblong to somewhat obovate, subacute to rounded above, acute to rounded at base and always decurrent onto petiole, 3-7 cm; scapes 1.5 - 3 dm; petals white, more or less veined with green; sepals triangular, about as broad as long, very shortly acuminate. Dry upland woods of Fauquier, Giles, Madison, Page, Rappahannock, Shenandoah and Tazewell Counties.

3. *Pyrola chlorantha* Sm. (*Pyrola virens* Schweigg.) Greenish-flowered wintergreen.

Leaves obovate to broadly elliptic or subrotund, rounded to truncate at summit, rounded to broadly cuneate at base but scarcely decurrent, 1-3 cm, often shorter than petiole; scapes 1-2.5 dm; petals 4-9 mm, white, more or less veined with green; sepals broadly ovate-triangular, broader than long, obtuse or subacute. Dry woods of Fairfax and Page Counties.

4. *Pyrola rotundifolia* L. Wild lily-of-the-valley. Muguet des Bois.

Leaves firm, mostly broadly elliptic to subrotund, 2.5-7 cm, broadly rounded above, rounded or truncate to short-cuneate at base, and always somewhat decurrent on petiole; scapes 1.5-3 dm, usually with 1 or 2 scale leaves; sepals oblong or ovate-oblong, 3-4 mm, nearly twice as long as wide, erose or undulate, not overlapping at base; petals white, 8-10 mm. Dry or moist woods and bogs west of the Fall Line.

## 7. Monotropaceae

Chlorophyll-less fleshy saprophytes obligately mycorrhizal; leaves reduced to scales, remote or crowded, flowers single or in a raceme; petals separate or united, 4-5; ovary 4-5 celled, style short, stigma capitate or broad, peltate, umbilicate; fruit an erect or nodding capsule; stamens 8-10, filaments slender, glabrous or pubescent, anthers opening by clefts, pollen grains borne singly. The following genera occur in North America: *Allotropa*, *Monotropa*, *Monotropsis*, *Newberrya*, *Pterospora*, *Pleuricospora*, and *Sarcodes*. Only *Monotropa* and *Monotropsis* occur in Virginia.

### Key to Species

1. Petals separate; capsules erect . . . . . 1. *Monotropa*  
1'. Petals united into campanulate or urceolate  
corolla; capsules nodding . . . . . 2. *Monotropsis*



1. *Monotropa* L.

White yellow, pink or red plants, turning black in drying, with erect stems beset with small scale-leaves, nodding flowers the same color as the stems, and erect dry fruits; corolla urceolate or broadly tubular; sepals 0-5; petals 4-5, distinct, all or some saccate at base; capsule ovoid to subglobose, loculicidal.

## Key to Species

1. Flowers solitary . . . . . 1. *M. uniflora*  
 1'. Flowers few to many . . . . . 2. *M. hypopithys*

1. *Monotropa uniflora* L. Indian pipe. Corpse plant. Convulsion root. Fitsroot.

Stems 1-2 dm, usually solitary, commonly waxy white, rarely pink or red; flower solitary, nodding, odorless, 10-17 mm; sepals often none; petals broadly oblong, slightly widened distally. Rich woods throughout the state.

2. *Monotropa hypopithys* L. Pinesap. False beechdrops.

Stems 1-3 dm, often gregarious, yellow, tawny, pink or red, more or less pubescent; raceme dense, at first nodding, erect at anthesis; flowers 8-12 mm, the lower usually tetramerous, the terminal often larger and pentamerous; sepals lanceolate, erect. Usually in acid soil throughout the state.

2. *Monotropsis* Schw.

Purple or brownish-purple plants 0.5-1 dm high, the simple stems beset with ovate scales; raceme at first nodding, erect at anthesis; corolla gamopetalous, cupulate, 5-cleft; sepals 5, erect; capsule ovoid, with a short and thick style, and a large 5-angular stigma.

*Monotropsis odorata* Ell. Sweet pinesap. Pigmy pipes.

Stems 5-12 cm; flowers pinkish, 1 cm, nearly equaled by the ovate bracts, with the odor of violets; sepals lanceolate, about equalling the corolla; corolla rather fleshy, persistent, the lobes ovate-oblong, shorter than the tube. Dry woods scattered throughout the state.

## SELECTED LITERATURE

- Cronquist, Arthur. 1968. The Evolution and Classification of Flowering Plants. Houghton Mifflin Company, Boston. 396 p.  
 Fernald, M. L. 1970. Gray's Manual of Botany, 8th Ed. D. Van Nostrand Company. New York. 1632 p.  
 Gleason, H. A. and Cronquist, A. 1968. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Hafner Publishing Company, Inc. New York. 3 Vols. 595 p.  
 Gleason, H. A. and Cronquist, A. 1965. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. D. Van Nostrand Company, Inc. Princeton, NJ. 810 p.  
 Lawrence, George H. M. 1970. Taxonomy of Vascular Plants. Macmillan Company, New York. 823 p.  
 Roane, Martha K. 1975. Rhododendrons native to Virginia. Virginia Jour. Sci. 26:6-12.

- Strasbaugh, P. D., and Core, E. L. 1978. Flora of West Virginia, Ed. 2. Seneca Books, Inc. Grantsville, WV. 1079 p.
- Uttal, L. J. 1987. The Genus *Vaccinium* L. (Ericaceae) in Virginia. *Castanea* 52:231-255.

## ADDITIONAL READINGS

- Harvill, A. M., Jr., Bradley, T. R., Stevens, C. E., Wieboldt, T. F., Ware, D. M. E., and Ogle, D. W. 1986. Atlas of the Virginia Flora, 2nd Ed. Virginia Botanical Associates. Farmville, VA. 23901.
- Massey, A. B. 1961. Virginia Flora. Va. Agr. Expt. Sta. Tech. Bull. 155. Blacksburg, VA. 258 p.
- Radford, A. E., Ahles, H. E., and Bell, C. R. 1967. Manual of the Vascular FLora of the Carolinas. University of North Carolina Press, Chapel Hill. 1183 p.

## **1988 Directory of the Virginia Academy of Science**

The official Directory of the Virginia Academy of Science has traditionally been printed and mailed separately to all members of the Academy during the summer. It was recently decided by the Council of the Academy that beginning in 1989 the Directory will be published (along with abstracts of papers presented at the annual meeting) in the Proceedings issue. Because of the delays I have experienced in putting together the 1988 Directory, we have judged that the value of this 1988 Directory is primarily historical, since two thirds of the Academy year was over before it was completed. Therefore, it is being presented here as a historical record of those holding Academy offices during the 1988 Academy year.

This Directory will be superceded by the 1989 Directory to be published in the 1989 Proceedings issue.

Stewart Ware  
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The Jeffress Memorial Trust is administered by Sovran Bank, N.A. Additional information about the program of the Trust may be obtained by writing to: Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, Trust Department, Sovran Bank, N.A., P.O. Box 26903, Richmond, Virginia 23261.

Roddy V. Amenta, James Madison University. A Computer Model for Developing Fabrics in Polycrystalline Solids, Part I: Igneous Rock Fabrics in Two Dimensions. \$31,557 (one year).

Geoffrey F. Birchard, George Mason University. Gaseous Diffusion Rate and the Functioning of the Insect Respiratory System. \$11,260 (one year).

David S. Cafiso, University of Virginia. Electric Field Effects on Lipid Bilayer Structure. \$51,385 (three years).

David F. Cox, Virginia Polytechnic Institute and State University. Investigation of the Role of Surface Defects in the Formation and Reactivity of Oxygenated Hydrocarbons Intermediates on a Metal-Oxide Surface. \$37,505 (three years).

J. B. Delos and S. K. Knudson, College of William and Mary. Order and Chaos in Quantum Mechanics. \$68,085 (three years).

Mark W. Fariss, Virginia Commonwealth University. What Makes Vitamin E Succinate a Unique and Potent Cytoprotective Agent? \$38,000 (one year).

Richard J. Freer, Virginia Commonwealth University. Computer-aided Molecular Design: An Approach to Understanding Ligand/Receptor Interactions. \$45,501 (two years).

Emma W. Goldman, University of Richmond. Eliminations from Silicon in Transition Metal Complexes. \$7,900 (one year).

R. Heather Macdonald, College of William and Mary. Depositional and Diagenetic History of Carbonate Concretions in the Devonian Millboro Shale, Virginia. \$9,463 (two years).

Joseph S. Merola, Virginia Polytechnic Institute and State University. Carbon-Hydrogen Bond Activation with Halide-Containing Iridium Complexes. \$49,600 (three years).

- Orson K. Miller and Ivano L. Brunner, Virginia Polytechnic Institute and State University. A Study of Ectomycorrhizae Associated with *Alnus serrulata* (AIT.) Willd. In Virginia.
- Aaron L. Mills, University of Virginia. Mineralogical and Hydrological Controls on Bacterial Transport in Porous Media. \$7,117 (one year).
- Ravinder K. Mittal, University of Virginia. Modulation of Esophageal Contractions and Peristalsis by Preload and Afterload. \$43,258 (two year renewal).
- Christopher J. Osgood, Old Dominion University. Regulation of Retrovirus-Like Elements in *Drosophila*. \$20,334 (two years).
- John R. Palisano, Emory and Henry College. The Origin and Role of Multilamellar Endoplasmic Reticulum. \$8,255 (one year).
- Richard D. Pearson, University of Virginia. Mechanisms of Wasting in Chronic Infection. \$20,000 (one year renewal).
- Hilary A. Perr, Virginia Commonwealth University. Human Intestinal Muscle Proliferation, Collagen Synthesis and Contraction. \$21,650 (one year).
- William A. Petri, Jr., University of Virginia. Sequence and Structure of *Entamoeba histolytica* Adherence Lectin. \$46,458 (two years).
- Jonathan I. Ravdin, University of Virginia. Isolation and Characterization of the *Entamoeba histolytica* Genes Which Code for Antigenic Proteins. \$34,250 (two years).
- Guillermo G. Romero, University of Virginia. Studies on the Second Messengers of Insulin Action. \$423,391 (one year).
- Mark Rosenkrantz, Virginia Commonwealth University. Regulation of Citrate Synthase Genes in *Saccharomyces cerevisiae*. \$22,000 (two years).
- Thomas O. Sitz, Virginia Polytechnic Institute and State University. Characterization of a Transfer RNA Ribose Methyltransferase Isolated from Ehrlich Ascites cells. \$37,500 (three years).
- Albert T. Sneden, Virginia Commonwealth University. Chemical Investigation of Medicinally Useful Plants of the Peruvian Amazon. \$28,824 (two years).
- James M. Tanko, Virginia Polytechnic Institute and State University. Competitive Cage Kinetics: Uses and Implications. \$49,933 (three years).
- C. Richard Terman, College of William and Mary. A Study of Socially Induced Contraception: Clarification of Mechanisms. \$15,400 (two years).
- David W. Thompson, College of William and Mary. The Synthesis of Selectively Substituted Olefins via Ether Cleavage of 3-Alkylidene-tetrahydrofurans. \$11,000 (one year).
- Michael P. Timko, University of Virginia. Cloning of a Benzoquinone Receptor involved in the Induction of Haustorial Formation in *Stringa asiatica* (Witchweed). \$24,750 (two years).
- Linda L. Vahala, Old Dominion University. Close-coupled Theory for the Lorentzian Line Shapes in Oxygen Schumann-Runge Predissociation and Its Comparison to the Results for Multi-channel Quantum Defect Theory. \$11,000 (one year).

Robert C. Whisonant and Jonathan L. Tso, Radford University. Tectonics and Sedimentation Along an Ancient Continental Margin, Southwestern Virginia Blue Ridge. \$27,965 (two years).

Raphael J. Witorsch, Virginia Commonwealth University. The Role of Placental Lactogen in Alcohol Induced Intrauterine Growth Retardation. \$52,750 (two years).



## MOUNTAIN LAKE BIOLOGICAL STATION SUMMER FIELD COURSES 1989

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(June 11 - July 15)

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Kansas State University

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VPI & SU

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Jerry O. Wolff

Villanova University

#### Workshop in Allozyme Techniques

Charles T. Werth

Texas Tech University

### Second Term

(July 16 - August 19)

#### Community Ecology

Joseph Travis

Florida State University

Henry M. Wilber

Duke University

#### Mammalogy

Jack A. Cranford

VPI & SU

#### Workshop in Mitochondrial DNA

(July 16 - July 29)

O. Colin Stine

Johns Hopkins University

#### Workshop in Molecular Techniques for Field Biology

(July 30 - August 19)

Daniel J. Burke

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University of Virginia

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For further information and application, write to:

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Three complete copies of each manuscript and all figures are required. It is also suggested that authors include a 5.25 diskette in IBM<sup>®</sup> compatible format containing a text file (ASCII) of the manuscript. Original figures need not be sent at this time. *Authors should submit names of three potential reviewers.* All manuscripts must be double-spaced. The title, author's name, affiliation and address should be placed on a cover page. An abstract (*not to exceed 200 words*) summarizing the text, particularly the results and conclusions, is required. The text should follow the general format used by professional journals in the author's discipline. Literature cited in the text should follow the name-and-year: Fujishima and Honda (1972). In the Literature Cited section at the end of the article each reference should include author(s), year, title of article, title of journal (using standard abbreviations), volume number and first and last page of the article. For a book, include author(s), year, title, pages or number of pages, publisher and city of publication. Examples:

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# VIRGINIA JOURNAL OF SCIENCE

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**Abstracts of Papers Presented at the  
Sixty-seventh Annual Meeting, Virginia Academy of Science  
May 23-26, 1989, Virginia Commonwealth University, Richmond, VA**

**Aeronautical and Aerospace Sciences**

**EFFECT OF GRID ADAPTATION ON COMPUTING MIXING HYPERSONIC AND SUPERSONIC FLOWS.** O. Baysal and M.E. Eleshaky, Mechanical Engrg. and Mechanics Dept., Old Dominion Univ., Norfolk, Va. 23529. Flow adaptive gridding is applied to the numerical studies of the viscous mixing between a scramjet nozzle flow and a hypersonic free stream to evaluate its effects on the solution accuracy. This scheme utilizes a tension and torsion spring analogy. In this study, the supersonic jet flow may consist of either air or a multispecies gas (Freon-12 and Argon mixture) simulating the combustion products. Two numerical schemes (an explicit finite difference and an implicit finite volume scheme) are used to solve the unsteady compressible, two-dimensional Navier-Stokes equations for multispecies gases. The initial solution is obtained on a stretched, but fixed grid. Then the grid is adapted to the flow and the solutions are recalculated. The results of the fixed grid and the adapted grid are compared with the experimental wind tunnel test results. The present work shows that the grid adaption improves the solution accuracy in the regions of high flow gradients and reduces the computational errors.

**COMPUTATIONAL STUDY AND VISUALIZATION OF FLOWS PAST RECTANGULAR CAVITIES.** O. Baysal and G. W. Yen, Old Dominion University, Norfolk, VA 23529

Computational simulations are performed for transonic and supersonic turbulent flows over deep and shallow three-dimensional cavities. Length-to-depth ratio of the cavities are varied from 3 to 16. Freestream values of Mach number are varied from 0.58 to 2.16, and Reynolds number is varied from  $5.02 \times 10^6/m$  to  $6.56 \times 10^6/m$ , at a total temperature of  $585^\circ R$ . Simulations of these oscillatory flows are generated through time-accurate solutions of Reynolds-averaged full Navier-Stokes equations using the explicit MacCormack scheme. The effect of turbulence is included through the Baldwin-Lomax model with modifications to correct the length and velocity scales in regions of separation and near three-dimensional corners. The results include instantaneous and time-averaged flow properties everywhere in the computational zone and time-series analyses of pressure on the floor and on the front face of the cavity. The solutions are validated through comparisons with experimental data. The features of deep and shallow cavity flows and effects of the third-dimension are illustrated through computational graphics. The cavity acoustics and the unsteady, three dimensional separation phenomenon are analyzed.

**GROUND-BASED EXPERIMENTS IN HYPERSONICS.** Gregory M. Buck, Exper. Aero. Branch, Space Systems Div., NASA Langley Research Center, Hampton, Va. 23665. Ground-based experimental techniques used in the development and testing of hypersonic vehicles are presented. Programs requiring ground-based hypersonic testing include an aeroassist flight experiment for development of orbital transfer technology, high-energy aerobraking vehicles for planetary return missions, an advanced space transportation system such as a second generation shuttle, assured crew return capability concepts, and the National Aero-Space Plane (NASP) program which calls for development of an advanced air-breathing Earth-to-orbit vehicle. Technical issues pertinent to hypersonic vehicle development and ground test philosophy are discussed. Hypersonic ground tests presently utilize conventional-type wind tunnels and impulse hypervelocity facilities such as shock tunnels and ballistic ranges. Advanced concepts for future hypersonic facilities are also presented. Illustrations of test measurement techniques used in conventional wind tunnels and utilization of experimental databases for vehicle aerodynamic/aerothermodynamic design, CFD code calibration/verification, and basic aerophysics studies are discussed.



**AN EVALUATION OF LEADING- AND TRAILING-EDGE FLAPS ON SUPERSONIC DELTA WINGS.**

Gloria Hernandez, Supersonic/Hypersonic Aerodynamics Branch, NASA Langley Research Center, Mail Stop 170, Hampton, Va. 23665-5225. An experimental investigation has been conducted to evaluate the effectiveness of leading- and trailing-edge flaps on a flat and cambered wing at supersonic speeds. Experimental testing was conducted in the low Mach number test section of the Unitary Plan Wind Tunnel at Mach numbers of 1.6, 1.8, 2.0 and 2.16. The study geometry consisted of a clipped delta planform with leading edge swept back  $50^\circ$  and trailing edge swept forward  $25^\circ$ . The cambered wing was designed for a lift coefficient of 0.3 at a Mach number of 1.8. Both wings were attached to a generic fuselage and both were configured with identical leading- and trailing-edge flaps. Results from the experimental tests showed that highly complex and three-dimensional flow can occur over the wings with leading- and/or trailing-edge flaps deflected. An analysis of the data also showed that flap effectiveness varies significantly between a cambered and flat wing of identical planform and flap geometry. Mach number effects are similar for both flat and cambered wings for all aerodynamic parameters.

**INCIPIENT SEPARATION ON SUPERSONIC DELTA WINGS.** S. N. McMillin, Supersonic/Hypersonic Aerodynamics Branch, NASA Langley Research Center, Mail Stop 170, Hampton, Va. 23665-5225. A computational parametric study was conducted to determine the effect of leading-edge radius and camber on the formation of incipient leading-edge separation over the leeward side of delta wings at supersonic speeds. The conical geometries examined in this study were three uncambered  $65^\circ$  swept delta wings which varied in leading-edge radius only and three  $65^\circ$  swept rounded leading-edge delta wings which varied in spanwise camber. Conical Navier-Stokes solutions were obtained at  $M = 1.6$ . Reynolds number was held constant at 1,000,000 and the Baldwin-Lomax turbulence model was used. The results showed by varying leading-edge radius and/or camber, the onset of leading-edge separation can be delayed to a higher angle of attack than observed on a flat sharp-edge wing. Based on the geometries studied, three wind-tunnel models are being designed to verify these results. The models are to be tested over a Reynolds number range of  $2 \times 10^6/\text{ft}$  to  $8.5 \times 10^6/\text{ft}$ .

**INTEGRATED GEOMETRY MODELING APPLICATIONS.** Mark L. McMillin, Space Systems Division, NASA Langley Research Center, Hampton, Virginia 23665-5225. A solid modeler has been developed for use with the Aerospace Vehicle Interactive Design (AVID) system at the NASA Langley Research Center. The SMART (Solid Modeling Aerospace Research Tool) package provides designers with the capability to quickly and accurately generate vehicle geometries that are used in aerodynamic and structural analyses. The geometry modeling program allows the user to create and modify configurations in real time. The display of realistic color images of a defined vehicle allows quick visual inspection for design flaws. The ability to calculate geometric properties in a hierarchical data base environment is also provided. Computational fluid dynamics (CFD) and finite element model (FEM) gridding and meshing techniques are currently under development. The productivity and creativity of the design engineer have been substantially enhanced due to the highly dynamic interactive nature of the program.

**RESEARCH AND DEVELOPMENT TRENDS FOR TRANSPORT AIRPLANES.** M. Leroy Spearman, NASA Langley Research Center, Hampton, Virginia 23665-5225. Commercial air transportation began in the U.S. in the mid 1920's, initially with mail service and soon followed by daring persons willing to wear helmets, goggles, and parachutes and to fly in open cockpits. The newly created NACA was, at the same time, getting involved in research and development activities intended to assure world leadership in aeronautics for the U.S. The impact of such activity on commercial air transportation will be outlined. Research areas that will be mentioned include aerodynamics, structures and materials, propulsion, and avionics. The application of this research to the design of transport airplanes will be discussed with particular regard to the availability of new technology in relation to the acceptance of the new technology. It will be pointed out

## Agricultural Sciences (*Did not meet this year*)

## Astronomy, Mathematics, and Physics

IN SITU RESISTIVITY MEASUREMENTS OF THE BiPb SUPERCONDUCTING SYSTEM DURING THE ANNEALING PHASE AS A PREDICTOR OF SUPERCONDUCTING PROPERTIES. Bruce Almeida, Keel Anthony, R. Caton, R. Selim, Department of Physics and Computer Science, Christopher Newport College, Newport News Va., 23606.

Four wire resistance measurements were made during the processing of  $\text{Bi}_{1.8}\text{Sr}_2\text{Cu}_2\text{Pb}_{0.6}\text{O}_x$  samples using silver leads pressed into the sample with the appropriate geometry. A fifth lead is also imbedded into the sample to thermally bond a type R thermocouple to the sample. Pt leads are then welded to the Ag leads to allow electrical contact at the high processing temperatures around 800-850°C. The samples are then placed into a tube furnace and the signals are brought out of the oven and interfaced to the data acquisition system. The instrumented sample, along with others from the same batch, were then annealed in air. Resistance data as a function of time and temperature were acquired. Samples were then removed at intervals and a study of the superconducting properties was performed. The correlation of the high and low temperature data is discussed.

MICROCOMPUTER-BASED CONTROL AND DATA ACQUISITION OF UNDERGRADUATE PHYSICS EXPERIMENTS\*, B. Michelle Burt\*, D. G. Meekins\*, and G. R. Taylor, Jr., Dept. of Physics, James Madison University, Harrisonburg, VA 22807. As part of a laboratory instrumentation improvement project, software for a microcomputer-based experiment control and data acquisition system was developed. The software was written in advanced basic and designed to control analog to digital and digital to analog conversion for an IBM PC compatible computer. Multiple circuits were designed and interfaced with the conversion boards to drive the Franck Hertz experiment and perform various plasma diagnostics. A package is being developed for use in undergraduate physics laboratory classes which will allow students to become familiar with interfacing and microcomputer based experiment control.

\*Supported in part by an NSF-ILI grant.

SCIENCE AS LINGUISTICS/HOW MATHEMATICS CAN DESCRIBE THE NATURAL WORLD. Kenneth C. Jacobs, Dept. of Physics, Box 9661, Hollins Col., Roanoke, Va. 24020. In the pedagogy and practice of science it is commonplace to note that 'mathematics is the language of science'. Yet, while many can use the mathematical apparatus, very few ever question why mathematics works when it is so applied to the natural world. Albert Einstein more than once expressed astonishment that mathematics should work when applied in science! This paper explores the connections between science, mathematics, and the natural world. As intimated by Thomas Kuhn in his On The Nature of Scientific Revolutions, we argue that the primary connection is linguistics. Science can be thought of as an evolving sequence of increasingly-sophisticated 'languages', each with an attendant array of equivalent mathematical forms (in the logico-mathematical sense of Russell and Whitehead). Illustrative examples are presented from the history of science; we also propose a new way of looking at the mathematics of Special Relativity so as to better understand what 'tachyons' really are! (Research partially supported by Faculty Awards Grants from Hollins College.)



CALCULATION WHICH AVOIDS DIVERGENT-SERIES EXPRESSIONS FOR ENERGY AND CHEMICAL POTENTIAL OF THE ELECTRON GAS. Edward M. Kiess, Dept. of Physics, Hampden-Sydney College, Hampden-Sydney, VA 23943. A few statistical mechanics textbooks tell us that the usual derivations for energy and chemical potential of the electron gas lead to asymptotic series in powers of  $T$  (temperature), which diverge for any  $T > 0$ . A derivation which justifies the termination of the series expressions, and avoids the divergent series, is discussed.

SHAPE-PRESERVING QUADRATIC SPLINE INTERPOLATION. Maria H. Lam, Department of Computer Science, Hampton Univ., Hampton, VA 23668. Shape representation has been a central issue in computer graphics. Many physical phenomena involve curves and surfaces that are monotone or convex. Then the corresponding representation problem is: Given points  $x_1 < x_2 < \dots < x_n$  and values  $\{y_i\}_{i=1, \dots, n}$ ; find  $f$  such that

$$f(x_i) = y_i \quad i=1, 2, \dots, n$$

and  $f$  preserves the monotonicity and/or convexity of the data.  $f$  is usually found by piecing  $f_i$ 's together where  $f_i$  is defined over  $[x_i, x_{i+1}]$  and

$$f_i(x_i) = y_i, \quad f_i(x_{i+1}) = y_{i+1}.$$

Standard interpolants need not be monotone or convex even though they may match monotone or convex data. One approach to this problem is to use quadratic splines, together with carefully chosen derivatives to control the shape of the curve. We employ several methods to estimate the derivatives at the given data points and compare the quadratic splines generated from these methods. Result of this investigation will be presented. This research is supported by NASA under the grant NAG-1-948.

MATHEMATICAL MODELS OF TISSUE GROWTH. Sophia A. Maggelakis & J. A. Adam \*, Dept. of Math. and Stat., Old Dominion Univ., Norfolk, Va. 23529. Two diffusion models of tumor growth are presented in this paper. The basic feature of each model is the diffusion of growth inhibitor which is produced at a uniform rate within the necrotic core for the first model and within the living tissue for the second model. The effects of this mitotic inhibitor on the stability of tissue growth are discussed and the regions of stability are determined.

HARD-CORE LIGHT SOURCE FOR BLUE-GREEN LASER PUMPING.\* KINAM PARK, IN H HWANG AND KWANG S. HAN, Hampton Univ., Hampton, Va 23668 --A hard-core flashlamp (HCF)<sup>1</sup>, which has a coaxial geometry was improved for enhancement of blue-green laser output. The short pulses ( $\sim 2\mu s$ ) surface discharges were produced across the core insulator of alumina. Operation at high pressure ( $\sim 2$  atm) of argon fill gas significantly elevates the uv emission. The maximum laser output with LD490 dye exceeded 50 mJ. A quadratic increase of the blue-green laser output was observed as the fill-gas pressure increased to 1,500 Torr. The characteristics of the pumping source and optical coupling configuration indicate that the system can be developed for the more efficient excitation of near uv laser as compared with the conventional flashlamp.

\*Supported by ONR Grant No. N00014-89-J-1653.

1. K. S. Han et al, AIP Conf. Proc. 172 (1987).



HERMITE INTERPOLATION POLYNOMIALS--A NEW APPROACH TO HIGH-PRECISION CALCULATIONS OF PLANETARY ORBITS. Joseph W. Rudmin, Physics Dept., James Madison Univ., Harrisonburg, VA 22807. A new approach, using Hermite interpolation polynomials, is being developed for high-precision calculation of the long-term behavior of the solar system. The Hermite interpolation polynomial, an extension of the Lagrange interpretation and osculating interpolation polynomials, is a polynomial of degree  $3N-1$  which fits a set of  $N$  data points in value, slope and concavity. A Fortran computer code is being developed to compute the long-term behavior of the solar system and other  $N$ -body Newtonian systems by modelling the Cartesian coordinates of the planets using these polynomials. Advantages of this approach include relatively long non-uniform timesteps, low truncation errors, and the ability to include non-inverse square forces and non-heliocentric orbits. Possible applications include searching for chaotic behavior in the planetary orbits, looking for 26 M year cycles as an explanation for periodic extinctions, calculating more precisely earth-orbit variations used in orbit-forced glaciation theories, and simply including more bodies in solar-system calculations than have been used previously. The approach, its motivations, and preliminary results will be discussed.

NUCLEON-NUCLEON POTENTIAL CORRECTIONS. Vena L. Sinclair, Dept. of Physics, Hampton University, Hampton, VA 23668, & Warren W. Buck, Dept. of Physics, Hampton University, Hampton, VA 23668. Preliminary graphs of corrections to the non-relativistic NN potentials will be presented. The graphs are a numerical representation of semi-relativistic potentials presented earlier by Buck. The potentials presented consist of a combination of purely non-relativistic interactions and this semi-relativistic interaction. The standard One Boson Exchange interaction is employed throughout. (Sinclair began this work while a participant in the 1988 ODU-REU Program).

UTILIZATION OF COMPUTERS IN EXPERIMENTAL PHYSICS LABORATORY CLASS. D. D. VENABLE, Dept. of Physics, Hampton University, Hampton, VA 23668. In 1979, the physics department at Hampton University began incorporating microcomputers in the experimental physics classes taken by junior physics majors. The computers have been utilized for simulation of experiments, acquisition and analysis of data, word processing, graphics, and data storage and retrieval. Ideally, the student completes a computer simulation of a laboratory experiment before actually performing the experiment. The original Tektronix 4051 computers were replaced in 1982 with HP9816 computers and in 1988 we begin converting to Macintosh SE computers. The problems of converting systems and comparison of in house software to commercial software are discussed.

DEVELOPMENT OF A Ho:Tm:Cr:YAG LASER FOR MID-INFRARED LIDAR APPLICATION, Kyong H. Kim, Young S. Choi; Donald A. Whitney, Dept. of Physics, Hampton Univ., Hampton, Va. 23668, Norman P. Barnes, Robert V. Hess, Clayton H. Bair, and Philip Brockman, NASA Langley Research Center, Hampton, Va. 23665. Laser output energy, slope efficiency, threshold and pulselength were determined for a flashlamp pumped  $2.1 \mu\text{m}$  Ho:Tm:Cr:YAG laser as a function of operating temperature, output mirror reflectivity, input electrical energy and Q-switch opening time. The measured normal-mode laser thresholds of a Ho $^{3+}$ (0.45 at. %):Tm $^{3+}$ (2.5 at. %):Cr $^{3+}$ (1.5 at. %):YAG crystal ranged from 26 to 50 J between temperatures of 120 K and 200 K with slope efficiencies up to 0.36 % with a 60 % reflective output mirror. Lasing of the crystal was observed at  $2.091 \mu\text{m}$  and  $2.098 \mu\text{m}$ . Fluorescence measurements are presented as a function of temperature and input energy. (Supported by NASA NAG 1-877)

THE PENINSULA'S LOCAL PHYSICS ALLIANCE. Donald A. Whitney, Dept. of Physics, Hampton Univ., Hampton, Va. 23668, & Lilinau Gofney\*, York High Sch., Yorktown, Va. 23602. The local physics alliance on the Virginia peninsula includes high school and college instructors of physics and chemistry in Hampton, Newport News and Yorktown with the common goal of exchanging demonstrations, experiments, ideas, information and teaching methods. The alliance is the result of efforts by the local organization of college physics teachers: PEPSY to broaden its constituency as planned at the April 1988 AAPT/APS workshop on Local Physics Alliances. Further information can be obtained from the co-chairpersons Lilinau Gofney and Donald Whitney. (Supported by the American Physical Society)

## Biology

HEART FUNCTION IN SHARKS AND RAYS. Daniel C. Abel, Dept. of Biol. Sciences, Mary Washington College, Fredericksburg, Va. 22401. Elasmobranch fishes (sharks and rays) possess a four-chambered heart surrounded by a semi-rigid pericardium whose space connects to the peritoneal space by the pericardio-peritoneal canal (PPC). Heart function in elasmobranchs depends upon low (even subambient) pericardial pressure (PP). The function of the PPC, found only in this group and a few other fishes, has been obscure. A model of elasmobranch heart function was developed to take the PPC into account, using the horn shark (Heterodontus francisci). In this species, the PPC apparently compensates for the pericardial rigidity characteristic of this group by shifting pericardial fluid into the peritoneal space when pericardial pressure rises during feeding or swimming, or as a result of poor pericardial drainage. In this way the PPC protects the heart from dysfunction due to elevated PP.

SEASONAL DYNAMICS OF THE ANAL GLAND OF THE HISPID COTTON RAT, (SIGMODON HISPIDUS), Julie Winchell Averitt and Robert K. Rose, Dept. Biol. Sci., Old Dominion Univ., Norfolk, VA 23529-0266.

The cotton rat, Sigmodon hispidus, possesses a subcutaneous anal gland that is associated somehow with reproduction in males. Lying between the skin and the rump, this gland surrounds the rectum but is oriented toward the penis. The size of the gland correlates strongly with the sizes of seminal vesicles and of testes, suggesting that it may serve as a secondary sex organ and may be important in scent-marking or courtship behavior. When fully enlarged, the gland may constitute 1-2% of body weight. Because of the location, anal gland secretions could be delivered through feces, urine, directly through the urethra, or all of the above. Extracts of the gland, when placed in live traps in fields, were differentially attractive to cotton rats but a second field study, using water- and fat-soluble fractions of extract, produced a less clear result.



THE EFFECTS OF TOPOISOMERASE II INHIBITORS ON MORRIS HEPATOMA 7777 CELLS. Meredith S. Brooks\* and Rosemary Barra, Dept. of Biol. Sci., Mary Washington Col., Fredericksburg, VA 22401. Topoisomerase II is a nuclear enzyme which catalyzes the concerted breaking and rejoining of both strands of the DNA molecule. Inhibitors of this enzyme are currently used as chemotherapeutic agents for the treatment of various forms of cancer. In this study, three known topoisomerase II inhibitors, Adriamycin, Ellipticine and Actinomycin D, were evaluated for their cytotoxic effects on Morris hepatoma 7777 cells. Of the three drugs, Actinomycin D had the greatest effects on Morris hepatoma 7777 cells. The cytotoxicity of Adriamycin was significantly decreased at pH conditions above 7.8 and below 6.9. The results of this investigation also indicated that the cytotoxic effects of the drugs increased when the cells were treated at 42°C. The combination of pH 6.9, hyperthermia and Adriamycin increased the cytotoxicity of each individual treatment suggesting that they may exert a synergistic effect on the cells.

HIBERNATION IN THE EASTERN CHIPMUNK (*Tamias striatus*); AGE AND SEX SPECIFIC DIFFERENCES. J. A. Cranford, Department of Biology, Section of Ecology and Organismal Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, U.S.A. Evaluation of chipmunk hibernation strategies were carried under short photoperiod at two temperature's in the first year and under two photoperiod and temperature conditions in the second year. Forty two animals were initially started in late summer at 18°C on LD 16:8 but were changed to LD 8:16 and subdivided in fall to a 4° and 18°C group. Body weight dynamics, activity patterns, torpor patterns and food consumption were monitored. To insure that the field caught animals were all adults a morphometric analysis of museum specimens was carried out to establish firm characters for adult (1+ years old) identification. Ten animals were determined to be young of the year and were analyzed as a separate group. In the first year the cold-treated animals achieved peak body mass 30 days or more before the warm group. Cold treated groups exhibited torpor or semitorpid states after 30 days and for 100 days or more continued to go into and out of torpor. Sex specific differences in peak weights and torpor patterns occurred as well as age specific differences. Torpor or semi-torpid states were rarely observed in the warm-treated animals even though their body masses reached similar peaks. Young of the year reached peak mass later than adults and went into torpor less frequently. Body weight dynamics of field animals were similar to those of adults under short photoperiod and cold temperatures.

EVALUATION OF PROCEDURES FOR PREPARATION OF MURINE DECIDUAL CELLS. Andrew W. Davis and Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, VA 23284-2012. Several different mechanical and enzymatic cell dispersion techniques were compared to determine which would yield the greatest number of intact viable decidual cells from pregnant uteri of DBA/2J mice. Best results were obtained with a modification of the cell dispersion protocol of Gibson-D'Ambrosio et al. (In Vitro Cell Dev. Biol., 22:529-534, 1986). After removal of embryos and extraembryonic structures, uterine tissue was placed in phosphate buffered saline containing 0.1 mM EGTA, 0.1% methylcellulose, and 81.5 units/ml of collagenase (Worthington, CLS-2), minced, and incubated with frequent agitation at room temperature for 1 hour. The resulting cell suspension was washed twice with, and resuspended in, HEPES-buffered alpha minimal essential medium supplemented with glutamine, antibiotics, and 10% fetal calf serum. Approximately 80% of the resulting decidual cells were viable, as determined by trypan blue exclusion, and the yield of viable cells was approximately  $7 \times 10^6$  cells per gram of uterine tissue. Decidual cell suspensions prepared by this method contained a heterogeneous population of cell types including decidualized endometrial stromal cells, macrophages, and lymphocytes. Supported by the Undergraduate Research Grant Program at VCU.



SURVEY FOR ACANTHAMOEBA IN THE POTOMAC BASIN. Ralph P. Eckerlin, Natural Science Div., Northern Virginia Cmnty. Col., Annandale, VA 22003, & Thomas K. Sawyer, Rescon Associates, Royal Oak, MD 21662. Ten sites along the Virginia shore of the Potomac River between Turkey Run and Pohick Bay were sampled in May and August, 1988. From each site soil samples and small mammal fecal pellets were obtained. Samples were cultured on agar plates on which the bacterium Klebsiella aerogenes was growing. Amebae were isolated and identified on trophozoite and cyst characteristics. Soil samples yielded 7 species of Acanthamoeba reported in descending frequency for the 10 sample sites: A. polyphaga (10/10), A. hatchetti (8/10), A. rhyssodes (6/10), A. castellanii (5/10), A. culbertsoni (2/10), A. terricola (2/10), A. lenticulata (1/10). All but the latter two have been reported from chronic human eye infections, and all but A. culbertsoni and A. terricola are known to be pathogenic to experimentally infected mice. Only amebic strains tolerant of human body temperature are potentially pathogenic. In this study numerous isolates of A. hatchetti, A. rhyssodes, A. culbertsoni, and the A. lenticulata were cultured successfully at 37-39°C and are considered potentially pathogenic to humans. A. polyphaga was isolated from the feces of 3 of 12 Peromyscus leucopus and A. hatchetti from a single Rattus norvegicus. Thus, small mammals may play a role in cyst dispersal of Acanthamoeba species.

MAPPING ANTIGENIC SITES I  $\gamma$ -ZEIN BY SYNTHETIC PEPTIDES. Asim Esen, Dept. of Biol., Va. Polytechnic Inst. & State Univ. Blacksburg, Virginia 24061

The immunochemical data from studies with polyclonal antisera to  $\gamma$ -zein<sub>1</sub>, the 27 kD component of the maize prolamin zein, indicate that the region containing 8 tandem repeats of the sequence PPPVHL is the site of one or more immunodominant epitopes. In one case the entire antibody repertoire of an antiserum recognizes epitopes within this region. Three 17-mer oligopeptides corresponding to the predicted antigenic epitopes of  $\gamma$ -zein<sub>1</sub> were synthesized and reacted with three different anti- $\gamma$ -zein<sub>1</sub> sera. This was to map antigenic sites in the intact protein with special focus on the repeat region. These antisera yielded positive reactions with the 17-mer peptide (peptide 37) derived from the repeat region and little or no reaction with the other peptides. In addition, antiserum was raised to peptide 37, and it was found to react strongly both with the homologous antigen (peptide 37) and the intact  $\gamma$ -zein<sub>1</sub>. Peptide 37 was also shown to block the binding of antisera to  $\gamma$ -zein<sub>1</sub> in competition assays. Subsequent to these results, the shorter 6-mer (peptide 82) and 12-mer (peptide 80) versions of peptide 37 were synthesized and reacted with anti-peptide 37 serum and also with each of the three anti- $\gamma$ -zein<sub>1</sub> sera. All of the three peptides homologous to the repeat region reacted with anti-peptide 37 serum and with anti- $\gamma$ -zein<sub>1</sub> sera. In these reactions the reactivity and the blocking ability in competition assays increased in proportion to the length of the peptide. Based on these data, it was concluded that the repeat region of  $\gamma$ -zein<sub>1</sub> is the site of one more sequential immunodominant epitopes varying in length from 6 to more than 12 residues. The data also suggest that the repeat region is exposed on the surface of the folded protein and probably occur in a mobile and random state.

**CHOLESTERYL OLEATE: MOUNTING SEX PHEROMONE OF THE HARD TICK, *DERMACENTOR VARIABILIS* (IXODIDAE).** Hamilton, JGC\*, Sonenshine, DE, Department of Biological Sciences, Old Dominion University, Norfolk, Va, 23529, and Lusby, WR\*, Insect Hormone Laboratory, USDA, ARS, Beltsville, Maryland, 20705. In hard ticks, males identify females by contact with the non-volatile Mounting Sex Pheromone (MSP) on the surface of prospective mating partners. This report establishes the role of cholesteryl oleate as the MSP of the American Dog Tick, *Dermacentor variabilis*. This is the first report of a sterol ester serving as a sex pheromone in any arthropod. Steryl esters are shown to occur in four other species of hard ticks, *D. andersoni*, *Amblyomma americanum*, *A. maculatum* and *Hyalomma dromedarii*. Their presence may account for mating cross reactivity among these ticks.

THE COMPOSITION AND ROLE OF THE ORGANIC MATRIX FROM SPICULES OF THE GORGONIAN LEPTOGORGIA VIRGULATA. Roni J. Kingsley, Dept. of Biol., Univ. of Richmond, Va. 23173 & G. Mechanic\*, Dental Res. Ctr, Univ. of N.C., Chapel Hill, NC 27514. The gorgonian Leptogorgia virgulata contains microscopic, calcitic spicules which impregnate the coenenchyme of the colony. Decalcification of spicules reveals an organic matrix which may be divided into water insoluble and soluble fractions. The amino acid composition of the soluble fraction is highly acidic. The insoluble fraction displays characteristics typical of collagen. For example it displays a typical amino acid composition and behavior on SDS-PAGE gels. Furthermore, the reducible crosslink, DHLNL, is clearly detected in this matrix fraction. There is seasonal variation in the composition of the matrix, i.e. the collagen-like composition is most prevalent in the summer. The organic matrix is believed to be intimately involved in the regulation of spicule formation i.e. through nucleation and inhibition. The finding of the collagen-like nature of the insoluble fraction provides new information on this regulatory role.

THE ANALYSIS OF INTERNAL AND EXTERNAL FEATURES OF REPRODUCTION IN SMALL MAMMALS. Kenneth W. McCravy and Robert K. Rose, Dept. Biol. Sci., Old Dominion Univ., Norfolk, VA 23529-0266.

Reproduction in small rodents can be assessed internally by the presence of embryos or by convolutions in the cauda epididymides in males. Estimates of reproduction in living animals are cruder because the variables of relative nipple size and opening of the vagina or pubic symphysis, or testes position in males, are not true indicators of fecundity and fertility. Yet, ecologists usually rely entirely on external variables in their assessment of reproduction. For two long-term studies of reproduction in the genus Microtus, we compare the estimates of reproduction made on live animals (external) with those based on necropsy (internal) of those same individuals. Three variables were used for males: body weight, body length and testes position (abdominal vs scrotal). Five variables were considered for females: body weight, body length, relative nipple size, perforated (or not) vagina, and condition of the pubic symphysis. Logistic analysis was used to produce parameter estimates in the form of coefficients for the logistic equation. For two sexes of the two species, only in the male prairie vole was the model superior to testes position in predicting the level of reproduction of the individual.

BOREAL FLEAS OF THE SOUTHERN APPALACHIANS. H.F.Painter and R.P.Eckerlin, Nat. Sci. Div., Northern Va. Cmty. Col., Annandale, VA 22003. Data gathered during study of flea populations in the isolated boreal environments on the high ridges and mountaintops of the Appalachian chain from Virginia/West Virginia to northern Georgia is reported. Collection emphasized examination of nests of small mammals and was largely restricted to the fall, winter and early spring. A number of previously unreported boreal fleas were found and data gathered on distribution limits of other fleas. Host distribution was not necessarily limited to the boreal environment. New Appalachian records are Megabothris asio, Megabothris quirini and Nearctopsylla genalis. Boreal distribution is confirmed for Atyphloceras bishopi, Catallagia borealis, Hystrihopsylla tahavua and Opisodasys pseudarctomys. Morphological differences seen in populations of Nearctopsylla and Catallagia borealis could point to ongoing speciation.



EFFECTS OF NUTRIENT ENRICHMENT AND LIGHT REDUCTION ON EPIPHYTE ACCUMULATION ON ARTIFICIAL EELGRASS. C. K. Phillips\* and A. F. Conway, Dept. of Biol., Randolph-Macon Col., Ashland, Va. 23005, and Kenneth Moore, VIMS/Col. of William and Mary, Gloucester, Va. 23062. Effects of nutrient enrichment and shading on epiphyte accumulation rates were studied using artificial eelgrass. Twenty-four running seawater aquaria in a greenhouse were randomly assigned to one of three shade levels and to one of two nutrient enrichment levels. Total epiphyte accumulation as dry mass was measured by scraping accumulated epiphytes onto pre-weighed filters and drying to constant weight. Organic mass was measured as the weight loss on combustion. Reduced light significantly reduced the rate of epiphyte accumulation, suggesting that epiphyte accumulation is dependent on photosynthesis and epiphytic algae are therefore critical in epiphyte accumulation. Elevation of nitrogen and phosphorus to three times the concentrations in York River seawater caused no significant change in rates of epiphyte accumulation, indicating that the current levels of these nutrients are not limiting epiphyte accumulation.

THE STATUS AND DISTRIBUTION OF THREE SMALL MAMMALS ENDEMIC TO THE GREAT DISMAL SWAMP OF VIRGINIA AND NORTH CAROLINA. Robert K. Rose, Dept. Biol. Sciences, Old Dominion University, Norfolk, VA 23529-0266

Three subspecies of small mammals, originally named as species shortly after their discovery during the first biological surveys in 1895, are considered to be endemic to the Great Dismal Swamp of Virginia and North Carolina. The Dismal Swamp southeastern shrew, Sorex longirostris fisheri, has been designated as "threatened" by the US Fish and Wildlife Service since September 1986, primarily because of threats to interbreeding with the upland subspecies, S. l. longirostris. No similar problem exists for the Dismal Swamp southern bog lemming, Synaptomys cooperi helaletes, because the nearest subspecies is in western Virginia. These mammals show good dispersing abilities and readily colonize oldfields, logged, burned, and replanted pine stands, and similar early successional stages, where they persist for about two decades, longer for the shrews. The Dismal Swamp short-tailed shrew, Blarina brevicauda telmalestes, at 13-15 g, is twice as heavy as the upland-dwelling southern short-tailed shrew, Blarina carolinensis. All three taxa seem to be restricted to damp organic soils of mesic habitats of the historic Dismal Swamp.

FOSSIL PLANTS OF THE HIGH ARCTIC. Stephen E. Scheckler and Stewart A. Hill, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. With James F. Basinger (Univ. Saskatchewan) over 400 kg of fossil plants were collected in 1988 from the Late Devonian (Frasnian) Nordstrand Point, Hell Gate, and Fram Fms. (Okse Bay Group) from southern Ellesmere Island, NWT, Canada along the flanks of Bird Fiord (ca. 77°07'N, 86°44'W). Only 2 other collections had been made from the Devonian strata of Ellesmere; Sverdrup's second (1898-1902) expedition (Nathorst 1904) and the 1962 expedition of Andrews, Phillips, and Radforth (1965). Both of these sampled the Fram Fm. at Goose Fiord and found only three species of two genera (Archaeopteris fissilis, A. obtusa, & Lyginodendron sverdrupi). We found these plus 7 new genera as well as 3 species never before collected at this paleolatitude for an increase of floral diversity of 400%. Present day Ellesmere was the NE tip of Late Devonian Laurentia at a paleolatitude of ca. 30°N. The new collections are compared to those from the Yukon Territory (then the NW tip of Laurentia at 30°N), Alberta, Maine, and New York (ca. 5-20°S). They suggest a previously unrecognized subtropical wet/dry biome for the Ellesmere communities, whereas the others seem to represent desert (YT) to circum-equatorial rain forest biomes.



VITELLOGENESIS IN THE IXODID TICK *HYALOMMA DROMEDARII*. Martin E. Schriefer and Daniel E. Sonenshine, Biomedical Sciences, Old Dominion University, Norfolk, Va. 23508. Egg yolk proteins, vitellins (Vns) of *Hyalomma dromedarii* were characterized on the basis of their molecular weights by column chromatography and polyacrylamide gel electrophoresis (denaturing and nondenaturing). Native vitellin was identified as an aggregate protein of approximately 450,000 daltons composed of seven major subunit polypeptides. Western blot analysis of tissue extracts demonstrated low (<1 ug/ul) levels of the Vn precursor vitellogenin (Vg) in both adult male and female hemolymph prior to blood feeding and in blood fed females prior to mating. Highest tissue levels of Vg or Vn were observed in the ovary and fat body of replete females. Quantitative analysis by enzyme linked immunoabsorption assay demonstrated a thirty fold increase of Vg concentration in hemolymph within two days of female repletion as compared to any earlier developmental or reproductive stage. In addition, synthesis and secretion of Vg was continued by isolated fat body tissues from mated females maintained in tissue culture medium. Endocrine regulation of Vg synthesis is currently being investigated.

AGGRESSIVE INTERACTIONS IN TWO SPECIES OF CARPODACUS FINCHES WINTERING IN VIRGINIA. Douglas H. Shedd, Dept. of Biol., Randolph-Macon Woman's Col., Lynchburg, VA 24503. Displacement interactions were recorded between house finches (*Carpodacus mexicanus*) and purple finches (*Carpodacus purpureus*) foraging at a bird feeder in Lynchburg, Virginia. Interspecific interactions were found to be significantly less common than expected, based on the relative frequencies of the two species competing for places at the feeder. The dominance of the house finches, combined with the relatively low level of intraspecific interactions, suggests that purple finches may have been avoiding encounters with house finches. In both species, male and female-plumaged birds interacted intraspecifically at the frequencies expected based on their relative frequencies in the population, with female-plumaged birds winning significantly more interactions.

DEGRADATION OF STORAGE PROTEINS IN THE PEANUT SEED DURING GERMINATION. E. H. Shokraji & A. Esen, Biology Dept., VPI & SU, Blacksburg, Va. 24061. Changes in the storage proteins (Arachin & Conarachin) of peanut (*Arachis hypogaea* L.) were studied during germination and seed development under controlled conditions. Electrophoretic and immunological techniques were employed for separation and identification of the individual storage protein subunits. The results indicate that there is a rapid rate of hydrolysis of major reserve protein fractions to the extent that more than 80% of the protein is depleted by day 14 of germination. The hydrolysis of the various polypeptides takes place at different rates. Some polypeptides are degraded completely at the early stage of germination while others are degraded gradually, some remaining the cotyledon for as long as 35 days after germination. These differences in the rates of degradation could provide information with regard to the possible site or function of each of the different polypeptides. As germination progressed, novel polypeptides appeared which are either the breakdown products of reserve protein subunits or newly synthesized proteins that have germination-related functions. There were no marked differences between the light and dark grown seeds except for the faster pace of protein degradation in the dark grown seeds during the first three weeks of germination.

A DESCRIPTIVE STUDY OF IMMUNOGLOBULIN DISTRIBUTIONS IN PLACENTAL, TROPHOBLASTIC, AND EMBRYONIC TISSUES OF NORMAL AND RESORBING CBA/J x DBA/2J HYBRID IMPLANTATION SITES IN CBA MICE. G. T. Stephens and A. F. Conway, Dept. of Biol., Randolph-Macon Col., Ashland, Va. 23005, and C. M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284. CBA/J female mice were mated with DBA/2J males. Large, small and visible resorbing implants were obtained on days 5.5 through 15 of gestation and embedded in glycol methacrylate. The localization of immunoglobulins (Igs) G, A, and M was studied following immunoperoxidase staining. All three Igs were observed in and around stromal cells of the mesometrial decidua, in cytoplasmic granules of trophoblastic giant cells (TGCs), and in the apical cytoplasm and on apical surfaces of parietal and visceral yolk sac (VYS) cells. Staining for IgA was consistently slightly more intense than staining for IgM which was usually slightly more intense than staining for IgG. The most intense staining was seen in the VYS epithelium and TGC granules on days 8 and 9. After day 8, staining for IgA, IgM, and IgG was less intense in small implants than in large implants. Resorptions stained less intensely for Igs than large or small normal implants of the same age. These results are consistent with a protective function for Igs during pregnancy.

EFFECTS OF DDT ON PLASMA VITELLOGENIN AND EGG MORPHOLOGY IN NORTHERN BOBWHITE. Joseph P. Sullivan, P.F. Scanlon, Dept. Fish and Wildl. Sci., G.E. Bunce, and R.W. Young, Dept. Biochem. and Nutrition, Va. Polytech. Inst. and State Univ., Blacksburg, VA 24061. At present no good method exists to predict the reproductive potential of birds exposed to environmental contaminants without the need for destructive sampling of either eggs or adults. Blood chemistries offer potential as a nondestructive means to assess reproductive potential in female birds. In this study, Northern Bobwhite (Colinus virginianus) were dosed with technical DDT to act as a model for organochlorine pesticide contamination. DDT was chosen because its effects on birds are best understood of the organochlorine pesticides, and its metabolite, DDE, is still being implicated in reproductive failures in wild birds. Vitellogenin, an important component of egg yolk, was measured in blood, and it and egg morphological measurements were related to DDT, DDE, and DDD residues in Bobwhite livers. Blood vitellogenin concentrations did not strongly correlate with liver residues of DDT and its metabolites. Morphological measurements of eggs did not change with dose group. No significant change occurred for blood vitellogenin among dose groups.

COMBINED EFFECTS OF MATERNAL AGE AND MATERNAL NUTRITION ON REPRODUCTIVE PERFORMANCE IN CD-1 MICE. Simeng Suy and Carolyn M. Conway, Dept. of Biol., Va. Commonwealth Univ., Richmond, VA 23284-2012. Female CD-1 Mus musculus at 3, 8, and 12 months of age were subjected to four different food regimes during their 1st pregnancy. Rodent laboratory chow or commercial dog chow was provided ad libitum prior to insemination and during week 1 of pregnancy, ad libitum or at 25% less than average daily consumption during weeks 2 and 3 of pregnancy, and ad libitum from parturition through weaning. The sequential effects on litter size, litter survivorship, and sex ratio at weaning were studied. A decline in litter size was observed as a function of maternal age. Although diet did not affect litter size at birth, effects on litter survivorship were observed for the 8 and 12 month old females that were on 25% food restriction. For older females receiving the 25% mouse chow restricted diet during gestation, none of the pups were viable at birth. In contrast, the majority of the pups born to older females receiving the 25% dog chow restricted diet and mouse chow or dog chow ad libitum survived to weaning. No differences in the sex ratio of offspring were observed for females receiving food ad libitum or at 25% restriction.



A FURTHER EXAMINATION OF REPRODUCTIVE PERFORMANCE IN THE LABORATORY BY WHITE-FOOTED MICE (PEROMYSCUS LEUCOPUS NOVEBORACENSIS) CAPTURED IN THE WILD. C.R. TERMAN, N. J. Anderson, and R. H. Mann., Lab. of Endo. & Pop. Ecol., Col. of William and Mary, Williamsburg, Va. 23185. Terman (1988, Va. J. Sci.) reported that the incidence of reproduction was greater ( $P < .001$ ) among wild P. l. n. males than females paired with nulliparous lab mates. Also, wild males sired fewer ( $P < .001$ ) young per litter up to four months after pairing than later. We investigated these phenomena further. From June through August, 1988, wild White-footed mice were paired with reproductively proven lab mice. As previously, more wild males than females reproduced but only at  $P < .1$ . The first litters of lab females sired by lab males averaged smaller ( $P < .001$ ) than the second litters born to these females but sired by wild males. Further, the third litters born to these females (the second litters sired by wild males) averaged larger ( $P < .02$ ) than the second litters, but not significantly different than the average of later litters. Thus, the sequence of litters was important in influencing litter size. All litters sired by wild males averaged more males than females ( $P < .1$ ). Supported by the Thomas F. and Kate Miller Jeffress Memorial Trust.

PREGNANCY BLOCK IN WHITE-FOOTED MICE (PEROMYSCUS LEUCOPUS NOVEBORACENSIS). C. R. TERMAN, D. A. Utt and J. D. Holley, Lab. of Endo. & Pop. Ecol., Col. of William and Mary, Williamsburg, Va. 23185. The capability of males who are strangers to recently inseminated females to block the implantation of blastocysts is known as the "pregnancy block" phenomenon and has been described in several species, among them the Prairie Deer Mouse (Peromyscus maniculatus bairdii) (Terman, 1969, An. Beh.). We report here on a series of studies of pregnancy block in our laboratory over several years involving hundreds of White-footed mice. These studies have demonstrated that recently inseminated females exhibit a great deal of variability of response and a high level of sensitivity to disturbances of various kinds (vaginal smearing, removal of the stud male, handling of the females) producing blockage of pregnancy. Supported by the Thomas F. and Kate Miller Jeffress Memorial Trust.

RESOURCE PARTITIONING IN DARTERS (PERCIDAE). Werner Wieland, Department of Biological Sciences, Mary Washington College, Fredericksburg, VA 22401. Resource partitioning is examined in the blackbanded (Percina nigrofasciata), bronze (P. palmaris) and muscadine (P. sp. cf. P. macrocephala) darters in an attempt to understand their complimentary distribution. Analysis of diet, time of feeding, and habitat utilization of allopatric populations indicated potential interaction between these species. Shift in habitat utilization by P. nigrofasciata in the presence of P. palmaris was observed, and along with decreased fitness of both species in syntopically occurring populations is considered as evidence of interaction resulting in ecological changes due to the presence of a competitor. Although suitability of habitat and other environmental variables are believed to be the primary factors which determine the range of a species, alteration in habitat utilization and decreased fitness due to the presence of a competitor are believed to affect how successfully a particular species can occupy a segment of stream and thus play some role in its distribution.



## Botany

DISTRIBUTION AND ECOLOGY OF NORTHERN WHITE CEDAR (THUJA OCCIDENTALIS L.) IN WEST VIRGINIA. H. S. Adams, Arts and Sciences, D. S. Lancaster Cmnty. Col., Clifton Forge, VA 24422, & S. L. Stephenson, Dept. of Biol., Fairmont State Col., Fairmont, WV 26554. Northern white cedar (Thuja occidentalis L.), a species with a distinctly northern distribution in North America, extends southward along the Appalachian Mountains to Tennessee and North Carolina. In West Virginia, white cedar has been reported from eleven counties, but relatively pure stands are found at only a few localities. Stands at two such localities—one near Circleville in Pendleton County and the other near the mouth of Second Creek in Greenbrier County—were sampled in the present study. At both localities, stands occur on rather steep, northwest-facing slopes in areas underlain by limestone. White walnut (Juglans nigra L.) is the only canopy associate at Second Creek, but ten other species occur in the canopy with white cedar at Circleville. Cored white cedar trees averaged  $160 \pm 11.5$  rings at Second Creek and  $61 \pm 5.6$  at Circleville. Growth patterns of the trees from both localities were remarkably similar over the past 25 years.

THE USE OF FREQUENCY OF DIVIDING CELLS TO ESTIMATE PICOPLANKTON PRODUCTIVITY IN THE LOWER CHESAPEAKE BAY. Lewis Affronti and H.G. Marshall. Dept. of Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. An estimate of primary productivity of picoplankton in the lower Chesapeake Bay was determined using frequency of dividing cells. In situ growth experiments of natural picoplankton were performed to establish a relationship between frequency of dividing cells and growth rate. The use of in situ incubations and natural populations of picoplankton should allow for a more realistic estimate of picoplankton growth rates compared to growth rates determined in the laboratory. High frequency sampling regimes employed in diel studies of picoplankton dynamics emphasizes the importance of studying this microscopic component at time scales that are comparable to its processes. From the established relationship of frequency of dividing cells and growth rate, picoplankton productivity/estimates can be made in concurrence with direct counting techniques. (Supported in part by Virginia State Water Control Board.)

COMPOSITION AND DISTRIBUTION OF RED SPRUCE FORESTS IN HIGHLAND COUNTY, VIRGINIA. Christopher Bailey and Stewart Ware, Dept. of Biol., Col. of William and Mary, Williamsburg, Va. 23185. Both woody and herbaceous vegetation were quantitatively sampled in sixteen red spruce, Picea rubens, stands in Highland County, Virginia. The stands occurred in two basic locations 1) above 1200 m on ridges and 2) in swamps along stream valleys. Red spruce was the most abundant species in all woody size classes. Acer rubrum, Betula lenta, and Prunus serotina were common associates. Herbaceous vegetation was categorized into 1) Dennstaedtia/Poaceae type, 2) Lycopodium spp. subtype, or 3) Dryopteris/Maianthemum subtype. The Dennstaedtia/Poaceae type occurred in close proximity to open pasture, while the Dryopteris/Maianthemum subtype was best developed at undisturbed sites. Ridge stands are old growth stands (many seed source trees are at least 80 years of age), and typically exhibit "inverse J shaped" size-class curves. Although, spruce reproduction is high under its own canopy the ecotonal boundary with the surrounding mature hardwood forest is sharp. Swamp stands are generally immature and exhibit "bell shaped" size-class curves. Field evidence and the available palynologic data suggests modern red spruce distribution is similar to its distribution before human influence. Red spruce abundance has been greatly influenced by Quaternary climatic fluctuations and regional physiography.

WATER QUALITY RELATIONSHIPS TO PHYTOPLANKTON ASSEMBLAGES IN THE LOWER JAMES, YORK, AND RAPPAHANNOCK RIVERS. Nancy Bland, Sean Morrison and H.G. Marshall. Dept. Biol. Sci., Old Dominion Univ., Norfolk, VA. 23529. Phytoplankton assemblages were associated with both seasonal changes and station sites located below the fall line during a 16 month study in these Virginia rivers. There were three station groups (Oligohaline, Oligo-mesohaline, mesohaline) and five seasonal sets that were associated with specific water quality parameters by discriminant analysis/MANOVA procedures. Winter-Spring groups were associated with increased DO,  $\text{NO}_3$ , pH, Chlorophyll b and c; with the summer to winter groups were characterized with increased dissolved phosphates,  $\text{NH}_4$ ,  $\text{NO}_2$ , secchi readings and salinity. Moving from Oligohaline to mesohaline stations the nutrient levels decreased. However, in comparing spring periods, the later onset of the spring freshet delayed nutrient enrichment and the spring bloom downstream. (Supported by the Virginia State Water Control Board.)

THE WINTER-SPRING PHYTOPLANKTON ASSEMBLAGE IN LAKE DURMOND, DISMAL SWAMP, VA. Christine Gregory and H.G. Marshall. Dept. of Biol. Sci., Old Dominion Univ., Norfolk, VA 23529. Phytoplankton samples were collected between Dec. 1988 and April 1989 to determine winter-spring assemblages. The dominant phytoplankters were diatoms, primarily Asterionella formosa, Melosira herzogii, pennates < 20 microns, and Fragillaria spp. The diatoms had a winter pulse in December and January, followed by a less intense peak in March. The most common winter diatom was A. formosa, reaching highest concentration in December and January. These were replaced in February and March by an assemblage of pennate diatoms. The pico-cyanobacteria cells were abundant with a mid-winter peak followed by more intense development in April. The chlorophytes, primarily composed of Microspora spp. and Mougeotia spp. were most numerous in January. The cryptomonads followed a similar pattern in abundance as the diatoms.

IDENTIFICATION AND LOCALIZATION OF METHYL SALICYLATE IN ROOTS OF VIOLA SUBGENUS MELANIUM. W. John Hayden & John Clough\*, Department of Biology, University of Richmond, Richmond, VA 23173. The aromatic roots of Viola arvensis and V. rafinesquii were studied in order to determine the chemical nature and anatomical localization of their volatile compounds. Gas chromatography and mass spectroscopy revealed a single detectable volatile compound, methyl salicylate (oil of wintergreen). Light microscopy and differential staining with Sudan III suggests the source of this compound to be enlarged secretory cells located in the endodermis. Secretory endodermal cells are sporadic in these two violets, but are most frequent in primary roots and less common in secondary roots and the lower portion of the hypocotyl.

SCANNING ELECTRON MICROSCOPE (SEM) STUDIES IN THE ASTERACEAE; FERREYRELLA, ILTISIA, MICROSPERMUM AND PIQUERIOPSIS. Miles F. Johnson, Dept. of Biol., Va. Commonwealth Univ., Richmond, VA 23284-2012. The study of microcharacters of the flower continues to play an important role in the systematics of the Eupatorieae Tribe in the Asteraceae. The base of the achene, the carpodium has been shown to be morphologically stable throughout the geographic range of the population in certain taxa of the Asteraceae. Does the carpodium morphology present taxonomically useful characters in these four specialized genera of the Eupatorieae? SEM shows the carpodium to be morphologically discontinuous between genera and therefore adds credence to previous studies. However, one author has placed Iltilsia in synonymy under Microspermum. The carpodium morphology as seen with SEM does not support this taxonomic decision. (Supported by the Department of Biology, Virginia Commonwealth University.)



THE PROTECTION OF RARE PLANTS THROUGH THE PROTECTION OF EXEMPLARY OR RARE NATURAL COMMUNITIES. J. C. Ludwig. Virginia Natural Heritage Program, 203 Governor Street, Suite 402, Richmond, VA 23219. The Virginia Natural Heritage Program protects rare and exemplary natural communities using a five step methodology. The first step, identification, involves the classifications of natural communities based on their physical parameters and dominant vegetation associations. The global and state rarity of each community is ranked to prioritize protection. Inventory is the second step which involves gathering information from many sources to collect site-specific data on each community type. Third, a preserve design is developed for the rare or exemplary community types. Protection, the ultimate goal, is realized in the fourth step when the Program works with land-management agencies and conservation organizations to execute the preserve design. The last step, stewardship, involves managing the land for the protection of the communities and the rare species within them. Case studies involving the classification and protection of Virginia's natural pond communities is presented.

BLOOM PRODUCING PHYTOPLANKTON WITHIN THE LOWER CHESAPEAKE BAY REGION. H.G. Marshall. Dept. Biol. Sci., Old Dominion Univ., Norfolk, VA 23529. Phytoplankton blooms in the lower Chesapeake Bay between 1986-1989 were few in number and limited to brief periods of high concentrations found in small or restricted areas of development. A bloom is defined as an expression of growth by a species that within a few days increases to concentrations that greatly exceed the normal or mean seasonal range of abundance previously recorded for the species in an area. Typical seasonal outbursts of growth are not included in this evaluation, with blooms frequently resulting in fish or shellfish kills and hypoxic conditions. Bloom events over this period were mainly associated with the dinoflagellates Prorocentrum micans, P. minimum, Heterocapsa triquetra, Glenodinium danicum, Noctiluca scintillans, Scrippsiella trochoideum and Katodinium rotundatum. The blooms occurred mainly in late summer and fall. More variable and with less frequency other bloom producing organisms during this period were several species of cyanobacteria, diatoms, euglenoids and chlorophytes. Supported by the Virginia Environmental Endowment.

PHYTOPLANKTON ASSEMBLAGES WITHIN THE LOWER JAMES, YORK AND RAPPAHANNOCK RIVERS. Sean Morrison, Nancy Bland, Kaleem Ahmed and H.G. Marshall. Dept. Biol. Sci., Old Dominion Univ., Norfolk, Va. 23529. Based on a 16 month study of phytoplankton at six stations located below the fall line in these three rivers, specific assemblages were related to station sites, in addition to those assemblages related in time to changing seasonal periods. There were 241 taxa identified, with three site groups with station salinity variations (oligohaline, oligo-mesohaline, mesohaline) and five temporal assemblages during this period, each with specific assemblages. Stream flow patterns (e.g. onset of the spring freshet) influenced nutrient levels, species distribution, timing of the spring pulse, and floral abundance downstream. Skeletonema potamos dominance declined abruptly in the oligohaline region to be replaced by Skeletonema costatum and Cyclotella caspia. Greater variance in composition was attributed to spatial (58%) effects, than to temporal (30%), with 12% associated to spatial-temporal interaction. (Supported by the Va. State Water Control Board.)



Where Are the Hickories in the Oak-Hickory Forest? Stewart Ware, Dept. of Biol., Col. of William & Mary, Williamsburg, Va. 23185. The Virginia Piedmont has been variously treated as Oak-Pine, Oak-Pine-Hickory, or eastern section of the Oak-Hickory Forest Region. Whatever the name, it has been assumed that, since pine is generally successional, oaks and hickories would dominate maturing hardwood forests. Sampling of 50 predominantly hardwood upland stands in the southern, south-central, north-central, and northern Piedmont revealed that indeed combined Quercus importance values ranked first in 49 stands and second in the 50th. The combined Carya values ranked first in one stand and second in 12 others, but were exceeded by one or more genera besides Quercus in 37 stands, and were not even in the samples in 9 of these. The inclusion of "hickory" in the name of the general forest type of the Piedmont seems to be based on either (a) presence of several species of Carya, rather than structural importance of these, or (b) a pre-conceived notion that hickories ought to be important where oaks are, or (c) a dismissal of the persistence potential of the genera (Acer, Nyssa, Liriodendron, Liquidambar) which most often exceed combined Carya importance. In contrast to the 50 stands above (on Paleozoic and Pre-Cambrian formations), combined Carya values were usually high in the Ca-rich, higher pH soils of the Triassic Leesburg Basin of Fairfax Co., Va.

#### INFLUENCE OF LITTER AND WATER REGIME ON EARLY ESTABLISHMENT OF PINUS PUNGENS.

Charles E. Williams, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. This study examined the effects of litter type (pine, hardwood, no litter) and water regime (1, 8, and 15 day intervals) on early establishment of P. pungens seedlings. Daily water/pine litter and litter-free treatments had the greatest seedling emergence (80%, 83%) and survival (98%, 99%) whereas seedling emergence in the daily water/hardwood litter treatment was considerably lower (56%) but survival comparable (96%). Seedling emergence and survival differed among 8 day water treatments: emergence was lowest (37%) but survival greatest (96%) in hardwood litter, emergence was highest (65%) and survival intermediate (88%) in pine litter, and emergence was intermediate (55%) and mortality complete in the litter-free treatment. Among 15 day water treatments, seedling emergence was high (61%) but survival low (1%) in pine litter, emergence was lower (30%) but survival highest (18%) in hardwood litter, and in the litter-free treatment emergence was negligible and no seedlings survived. Significant interactions indicated that the effects of litter and water regime on seedling emergence and survival were not independent; litter significantly decreased the loss of soil moisture and probably increased seedling emergence and survival at low water regimes.

SEEDLING HABITAT OF PINUS PUNGENS IN PINE-OAK FOREST: IMPLICATIONS FOR POPULATION MAINTENANCE. Charles E. Williams, Dept. of Biol., Va. Polytechnic Inst. & State Univ., Blacksburg, VA 24061. The seedling habitat or regeneration niche of Pinus pungens was examined in mature pine-oak forests in southwest Virginia. I measured seven variables that partially characterized the habitat of newly emerged P. pungens seedlings in three stands and compared this array to the same measurements made at random points within each stand. Seedlings were found in microsites characterized by lower litter depth, ground cover, canopy cover, and larger nearest neighbor distances than occurred at random. Additionally, seedlings established more often in pine litter and under pine-dominated or pine-oak canopies than in hardwood litter or oak-dominated canopies. Principal components analysis showed a clear separation of seedling and random points along two habitat gradients: Axis I was a gradient from low to high ground cover, canopy cover, and litter depth; Axis II was a gradient from pine to oak canopy and high to low nearest neighbor distance. There was little overlap in the distributions of variables for seedlings and random points suggesting that recruitment of P. pungens in pine-oak forest may be limited in part by microsite availability. (Supported by Sigma Xi and the VPI & SU Graduate Research Development Project).

THE EXPRESSION AND REGULATION OF ALPHA-AMYLASE BY GIBBERELLIN (GA) IN SEED AND SEEDLING ROOTS OF RICE (ORYZA SATIVA). Janet Wrestler\* and Mary A. Smith\*, Dept. of Biol., Univ. of Richmond, VA 23173. Expression of  $\alpha$ -amylase in barley seeds is regulated by GA released from the embryo, which stimulates transcription of the enzyme in the aleurone layer. This well accepted mechanism of expression is generalized to many cereal seeds. Characterizing hormonal regulation in rice seeds via isoelectric focusing reveals two major bands of  $\alpha$ -amylase activity and one major band of  $\beta$ -amylase activity. Embryoless half-seed studies revealed that GA stimulates  $\alpha$ -amylase activity, but the embryo does not appear to be required as a GA source. One  $\alpha$ -amylase band of activity is expressed in roots, and it comigrates with the dominant band of activity in the seeds. Although the seedling shoot responds to GA, the effect of the hormone on root  $\alpha$ -amylase activity is not clear.

RARE PLANTS AND THEIR COMMUNITIES IN SOUTHEASTERN CHESTERFIELD COUNTY, PARTICULARLY NEAR THE TOWN OF CHESTER. Robert A. S. Wright and Lyn Burton, Cent. Va. Biol. Res. Consortium, 5204 Riverside Drive, Richmond Virginia 23225. Despite continuing development pressure, especially for single-family housing, there remains in southeastern Chesterfield County a number of biologically-unique habitats in an area bounded by Interstate 95, Appomattox River and the drainage heads of Proctor's, Ashton, Timsbury and Swift Creeks. Noteworthy plants have been found in upland white-sand pine barrens, headwater swamps, creekbanks, meadows and seepages. Notable flora includes Dryopteris marginalis, Lycopodium alopecuroides, Rhynchospora fascicularis, Carex sparganoides, Eleocharis palustris, Xyris difformis, Habenaria blephariglottis, Sabatia difformis, Chelone uthbertii, Euphorbia ipecacuanhae, Schrankia microphylla, Cnidioscolus stimulosus, Galium uniflorum, Ampelopsis arborea, Listera australis, Lilium michauxii, Pinus serotina, Gentiana catesbeii, Amianthemum muscaetoxicum. There are few areas in Virginia which can boast of such an impressive list of rare and local flora. Unfortunately, Chesterfield's is disappearing.

THE GINSENG RECOVERY PROGRAM AT THE VIRGINIA PEAKS OF OTTER, BEDFORD/BOTETOURT COUNTIES, VIRGINIA: A SUCCESS STORY. Robert A. S. Wright, Cent. Va. Biol. Res. Consortium, 5204 Riverside Drive, Richmond, Va. 23225. Annual shoot growth, subsequential fruit recruitment and the ultimate survival of illegally-poached ginseng roots were investigated by National Park Rangers at the Peaks of Otter, Bedford/Botetourt Counties Virginia between 1980 and 1984. Roots found in unlawful possession were confiscated and promptly replanted into nine test plots; the plants' seasonal conditions were monitored. It was determined that an average of 55% of the poached roots were saved; poached roots regained fecundity rapidly producing 560 fruits, which represent some 1100 potentially viable propagules. The controversial "root dormancy" phenomenon was observed in replanted poached root plots. All data indicate that by implementing a ginseng recovery program in Federal and State parks a significant portion of poached ginseng returned to the soil within 24 hours can re-establish itself and resume fecundity. This conservation program may be initiated with a minimal cost and manpower loss. (Funded by National Park Service Res. Mngt. Pro. 0201)



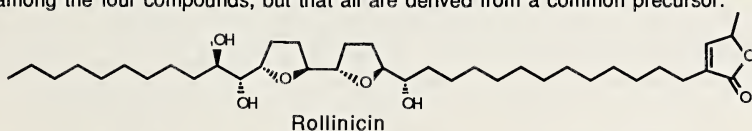
## Chemistry

### PHOTOCHEMISTRY OF SOME ANTHRAQUINONE-SUBSTITUTED BETA-CYCLODEXTRINS.

Christopher J. Abelt, Angela M. Aquino, and Sarah E. Kelley, Dept. of Chem., Col. of William and Mary, Williamsburg, Va. 23185. Irradiation of anthraquinone-2-sulfonyl, 1-sulfonyl, and 2,6-disulfonyl-beta-cyclodextrin gives rise to selective oxidation of the cyclodextrins via hydrogen abstraction by the excited quinone moieties.

### STRUCTURE DETERMINATION OF BISTETRAHYDROFURANOID ACETOGENINS FROM *ROLLINIA* SPECIES USING NMR. Milton J. Abreo and Albert T. Sneden, Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia 23284-2006.

*Rollinia papilionella* has been the source of four highly cytotoxic C<sub>34</sub> linear acetogenins, e.g., rollinicin, over the past seven years. All contain at least eight chiral centers. The relative configurations around the key structural feature, the bistetrahydrofuran moiety, may be determined by high field NMR studies of the peracetates. Application of this technique to the acetogenins isolated from *R. papilionella* led to the finding that two diastereomeric relationships exist among the four compounds, but that all are derived from a common precursor.



(Supported in part by the Biomedical Grant-in-Aid program of the College of Humanities and Sciences at Virginia Commonwealth University.)

QUANTUM CHEMICAL STUDY OF AN ANTI-INFLAMMATORY DRUG MOLECULE. Amy Aussiker and Steven G. Desjardins, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. A quantum chemical analysis of the drug N,N-diethyl-4-methyl-1-piperazine carboxamide (DEC) and seven proposed analogs at the INDO/CNDO level is presented. The study includes analysis of conformation, orbital structure and charge distributions. These studies are preliminary to considering QSAR correlations with the biological activities of these drugs. (See Medical Sciences section, 9:30, Thursday, May 25.)

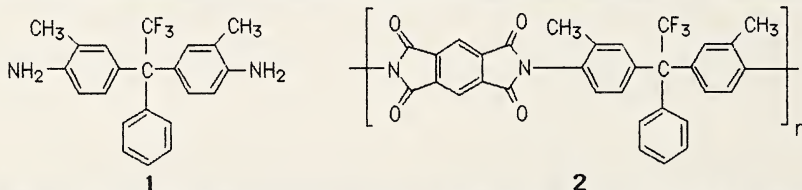
CHEMICAL STUDIES ON OXOMOLYBDENUM(VI) COMPLEXES AS BIOINORGANIC MODELS FOR THE MOLYBDENUM HYDROXYLASE ENZYMES. John O. Bachert, III, and Joseph Topich, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23284. Solution (DMF) FT-IR spectra have been obtained for cis-dioxo-Mo(VI) complexes containing tridentate Schiff base ligation, Mo(VI)O<sub>2</sub>(5-X-SSE, SSP, SAP, SAE). Correlations are observed in the FT-IR spectra of these complexes as a function of the X-substituent, and/or the Schiff base ligand. It is known that the Mo SSP and SSE complexes (i.e. those containing ONS ligand donor atoms) undergo oxygen atom transfer reactions with PEtPh<sub>2</sub> in DMF, where one of the cis-dioxo oxygens is transferred to the phosphine. These reactions can be characterized by a second order rate constant k<sub>1</sub>. Correlations are also observed between k<sub>1</sub> and the Mo=O stretching vibrations ( $\nu_{\text{Mo=O}}$ ) for the cis-dioxo-Mo(VI) moiety within these complexes. A mechanism for this reaction has been proposed involving the donation of the phosphine lone pair electrons into an empty oxo-O $\pi^*$  antibonding orbital of the cis-dioxo unit. The trends in the vibrational data for the SSP and SSE complexes reflect the variation in the energy of the oxo-O $\pi^*$  antibonding orbital. In view of the correlation between k<sub>1</sub> and  $\nu_{\text{Mo=O}}$ , the energy of the oxo-O $\pi^*$  antibonding orbital contributes to the energy of activation for this reaction. These data provide experimental support for the currently accepted oxo-atom transfer mechanism, and also represent the first systematic study of Mo=O stretching vibrations as a means of mechanistic elucidation in molybdenum enzyme models.



**HIGH PERFORMANCE POLYMERS: POLYPHENYLQUINOXALINES CONTAINING CARBONYL, ETHER, AND SULFIDE CONNECTING GROUPS.** R.G. Bass, R. O. Waldbauer, Jr., J. R. Mercer\* and Rooma Mago\*, Dept. of Chem., Virginia Commonwealth Univ., Richmond, Va. Polyphenylquinoxalines are high-temperature thermoplastics which exhibit high thermal stability and good mechanical properties. Since their initial disclosure in 1967, several routes have been investigated in an attempt to improve their processability without a major loss of thermal and/or mechanical properties. The incorporation of more flexible, less linear units into the polymer chain would be expected to lower the glass transition temperature and improve flow properties resulting in a more processable material. To test this hypothesis, a series of polyphenylquinoxalines were prepared from aromatic bis(*o*-diamines) and extended bis(benzils) containing carbonyl and ether connecting groups between the aromatic rings. These materials exhibited excellent thermal stability and mechanical properties. Further work is underway to prepare polyphenylquinoxalines containing carbonyl, ether, and sulfide connecting groups and to ascertain the effects of these structural variations on melt viscosity and thermal mechanical properties.

**TETRAPHENYLPORPHYRIN SYNTHESIS.** Lagree Michael Burke\* and Charles M. Bump, Department of Chemistry, Hampton University, Hampton, VA 23668. Tetraphenylporphyrins are traditionally synthesized by the condensation of a substituted benzaldehyde with pyrrole in acetic or propionic acid. Reaction of *p*-nitrobenzaldehyde and pyrrole gives good yield of tetra(*p*-nitrophenyl) porphyrin. Little or no porphyrin is obtained from benzaldehydes with electron donating substituents. Tetra(*p*-hydroxyphenyl)porphyrin can be prepared by reduction of tetra(*p*-nitrophenyl)porphyrin diazotization, and replacement of the diazo group by water.

**NEW CONDENSATION POLYIMIDES CONTAINING A PHENYLTRIFLUOROETHYLIDENE LINKAGE.** Margaret L. Crews\* and Roy F. Gratz, Dept. of Chemistry and Geology, Mary Washington College, Fredericksburg, VA 22401. Three new condensation polyimides were prepared from 1,1-bis-(4-amino-3-methylphenyl)-1-phenyl-2,2,2-trifluoroethane (DMDAM), 1. This diamine



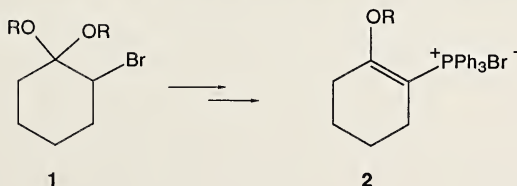
was reacted in dimethylacetamide with pyromellitic dianhydride (PMDA), 3,3',4,4'-benzophenonetetracarboxylic dianhydride (BTDA), and 2,2-bis(3,4-dicarboxyphenyl)hexafluoropropane dianhydride (6FDA) to form polyamic acid solutions which were cast into films and thermally imidized. The PMDA polymer is shown in structure 2. The polyimide films were characterized by thermomechanical analysis (TMA) and thermogravimetric analysis (TGA).

**ELECTROCHEMICAL STUDIES OF MONOLAYER AND BILAYER ASSEMBLIES ON SOLID ELECTRODES: CHARACTERIZATION AND APPLICATION TO BIO-ELECTROCHEMISTRY.** John K. Cullison and Fred M. Hawkrige, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284. Our laboratory is interested in incorporating biologically significant redox molecules into organized assemblies at the electrode surface. The electrochemical characterization of monolayers spontaneously adsorbed to gold substrates is reported. Preliminary results of bilayers formed by using the Langmuir-Blodgett method also are examined. The electrochemistry of Coenzyme Q present within these assemblies is discussed. Future directions of group research also are presented.

TWO SIMPLE THEORETICAL MODELS FOR CONFORMATION IN THE LIQUID STATE. G. Kathleen Duwel and Steven G. Desjardins, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. Conformational behavior for molecules whose excluded volume can change as a function of a single internal co-ordinate is studied using the breathing hard sphere (BHS) and static diatomic solvent (SDS) models. These models are far less numerically intensive than standard theories such as RISM, and results indicate good agreement with more sophisticated models when applied to the conformational behavior of liquid n-butane. Some results for high pressure liquid nitrogen will be discussed, as well as possible extensions to quantal intramolecular degrees of freedom.

The complexes of the lanthanide(III) ions having the general formula  $M(C_{22}H_{26}N_6)(CH_3COO)_2Cl \cdot nH_2O$ , in which M is La-Lu (except radioactive Pm),  $C_{22}H_{26}N_6$  is a six-nitrogen donor macrocyclic ligand, and n is 3-5, are unique among lanthanide complexes in that they are soluble in water as well as organic solvents without undergoing release of the metal ion. In contrast, the exocyclic ligands (anions or solvent) are rapidly exchanged. To evaluate the potential of these complexes as nuclear magnetic resonance shift reagents, we have carried out a proton and carbon-13 nuclear magnetic resonance study of all members of the lanthanide series. Comparison with similar studies on lanthanide phthalocyanines reveals interesting regularities.

$\alpha$ -Bromoketals **1** are derived from simple cyclic ketones and provide a direct route to  $\beta$ -alkoxyvinylphosphonium salts **2**. The results of these studies will be discussed.



**"Synthesis, Characterization, and Condensation Reactions of Dihydroxy-compounds Containing a Metal-macrocylic Core."**

W. A. Gootee, K. T. Pham, and L. M. Vallarino

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Richmond, VA 23284

Two series of novel  $\alpha,\omega$ -dihydroxy compounds, of the type  $M\{\text{macrocycle}(\text{ROH})_2\}(\text{CH}_3\text{COO})_n$ , have been synthesized, in which  $M$  = lanthanide(III), macrocycle =  $\text{C}_{22}\text{H}_{22}\text{N}_6$ , and  $R = -\text{CH}_2\text{C}_6\text{H}_4-$  or  $-\text{CH}_2-$ . These compounds were characterized by chemical and thermogravimetric analysis, and by a variety of spectral methods (infrared, proton and carbon-13 nuclear magnetic resonance, fluorescence). The reactivity of the peripheral -OH groups with mono- and difunctionalized acyl halides has been investigated, to develop a synthesis for polycondensation macromolecules containing sequestered paramagnetic metal ions.

**"Six-Nitrogen Macrocylic Metal Complexes with Peripheral Amino Functionalities: Synthesis and Properties"**

C. Gribi, D. L. Smailes, A. Twiford, and L. M. Vallarino

Department of Chemistry, Virginia Commonwealth University  
Richmond, VA 23284

Amino-functionalized complexes of several di- and trivalent metal ions, having the general formula  $M\{\text{macrocycle}(\text{CH}_2\text{C}_6\text{H}_4\text{NH}_2)_n\}\text{X}_n$  have been synthesized, in which  $M = \text{Sr(II)}, \text{Pb(II)}, \text{La(III)}, \text{Gd(III)}, \text{Eu(III)}$ ; macrocycle =  $\text{C}_{22}\text{H}_{24}\text{N}_6$ ,  $\text{X} = \text{CH}_3\text{COO}^-, \text{CF}_3\text{SO}_3^-, \text{SCN}^-$ ;  $n = 2$  or  $3$ . The complexes were yellow-orange solids, thermally stable and very soluble in organic solvents. Their structure and solution behaviors were investigated by chemical and thermogravimetric analysis, proton and carbon-13 nuclear magnetic resonance, and fluorescence spectroscopy. It was found that the metal-macrocylic entities are inert with respect to release of the metal ion, whereas the exocyclic anions are readily exchanged. The peripheral primary amino groups exhibited their typical behavior.

RESONANCE RAMAN SPECTROSCOPY OF CATALASE. Melissa Holmes and James Turner\*, Dept. of Chem., Va. Commonwealth Univ., Richmond, Va., 23284. This laboratory has previously reported the direct observation, using resonance Raman spectroscopy, of the  $\text{Fe(IV)=O}$  (oxo-ferryl) vibration in the activated intermediates of the heme enzyme horseradish peroxidase. Resonance Raman spectroscopic studies of the active site structure and dynamics have been undertaken for the heme enzyme catalase, which displays both catalatic and peroxidatic activity in the reduction of compound I. Compound I is the green primary intermediate formed upon addition of peroxide substrate to catalase and is a 2-electron oxidized species relative to the resting enzyme. When a one electron donor is used to reduce compound I, the secondary red intermediate compound II results. Analysis of the spin- and coordination-number-sensitive spectral bands of m. luteus catalase compound II, obtained using ethyl hydrogen peroxide as substrate, indicates that catalase compound II is six-coordinate, low-spin. The resting enzyme is five-coordinate, high-spin, while the fluoride and formate complexes are six-coordinate, high-spin.



**Computer Simulation of a Precipitation Titration with an Acid-Base Indicator for the Detection of the End Point.** Myung-Hoon Kim, Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23529, and Myung-Zoon Czae, Department of Chemistry, Hanyang University, Seoul, Korea 133-791.

Visual acid-base indicators have been used only for acid-base titrations in the past. This investigation is to extend the usage of the acid-base indicators for precipitation titrations as well. This is possible when a titrant cation (e.g.,  $\text{Ag}^+$ ) can form an insoluble salt with a conjugate base ( $\text{A}^-$ ) of a weak acid ( $\text{HA}$ ) as well as with an analyte ( $\text{X}^-$ ); the weak acid is added as a mediator for the response of an acid-base indicator. This presents a nice equilibrium problem in which an acid-base reaction is coupled to solubility equilibria. The system involves four equilibria and nine simultaneous equations, which are solved numerically with an iterative method for all equilibrium species present. The effects of the following factors are examined to attain a sharper and larger pH changes at the end point and to select a suitable indicator for a system: (1) solubility product ( $K_{\text{sp}}^1$ ) of  $\text{AgX}$ , (2) solubility product ( $K_{\text{sp}}^2$ ) of  $\text{AgA}$ , and (3) concentration ( $C_a$ ) and (4) dissociation constant ( $K_a$ ) of the mediator acid ( $\text{HA}$ ).

**ELECTRON TRANSFER AND LIGAND BINDING REACTIONS OF MYOGLOBIN.** Bertha C. King and Fred M. Hawkrige, Department of Chemistry, Virginia Commonwealth Univ., Box 2006, Richmond, VA 23284.

Heterogeneous electron transfer reactions of myoglobin have been studied under anaerobic conditions, with varying dioxygen concentrations, and with cyanide. Myoglobin reacts quasi-reversibly at indium oxide electrodes with a rate constant of  $2.0 \times 10^{-5}$  cm/s. Since dioxygen only binds to the reduced form of myoglobin, the electrode reaction under aerobic conditions can be modelled as an EC (electron transfer at an electrode followed by a chemical reaction in solution) mechanism.

While subtracting background voltammograms from results obtained in the presence of myoglobin and dioxygen, additional reductive currents not associated with the above reaction mechanism became evident. These results indicate that the oxidized form of myoglobin contains dioxygen not coordinated to the heme iron. This could be a direct measure of one of myoglobin's physiological roles, namely, facilitated oxygen transport.

**CHEMICAL STUDIES ON OXOMOLYBDENUM(VI) ORGANOMETALLIC COMPLEXES.**

Patrick M. Lamb and Joseph Topich, Dept. of Chem., Va. Commonwealth Univ., Richmond, VA 23284. Dioxo(dimethyl)(2,2'-bipyridyl)molybdenum(VI),  $\text{MoO}_2(\text{CH}_3)_2(\text{bipy})$ , and dioxo(dimethyl)(1,10-phenanthroline)molybdenum(VI),  $\text{MoO}_2(\text{CH}_3)_2(\text{phen})$ , are prepared from methyl magnesium chloride and  $\text{MoO}_2(\text{Br})_2(\text{bipy})$  and  $\text{MoO}_2(\text{Br})_2(\text{phen})$ , respectively. The syntheses of these organometallic compounds will be described in detail. The chemical properties and spectral characterizations will be presented.

GC/MS ANALYSIS OF FUELS DERIVED FROM SHALE OIL. George W. Mushrush and Wayne M. Stalick, Chemistry Department, George Mason University, Fairfax, VA 22030. Fuels deteriorate in quality with increasing time in storage. Nitrogen heterocycles are frequently related to this observed storage instability. In certain instances, direct autoxidation of nitrogen containing species is indicated, which may be subject to catalytic effects made possible by trace fuel components. In other instances, the organic nitrogen compounds themselves assume the role of catalysts in the oxidation of other fuel moieties. This paper will describe the separation of both polar and non-polar nitrogen extracts from a marginally stable high-nitrogen shale jet fuel. This separation was effected by first treating the fuel with HCl. The subsequent acid extract was neutralized and then extracted with methylene chloride and consisted primarily of basic nitrogen compounds (BNC's). The acid extracted fuel was then treated with silica gel. Two fractions which included non-basic nitrogen compounds (NBNC's) were obtained by selectively desorbing the silica gel with methylene chloride followed by methyl alcohol. These three nitrogen compound extracts were analyzed and characterized by combined capillary column GC/MS.

PREPARATION OF POLYIMIDES FROM BIS(DIENES) OF HINDERED ARYL DIAMIDES AND BISMALIMIDES. Raphael M. Ottenbrite and Joseph G. Smith Jr., Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia 23284

The Diels-Alder polymerization of bis(3,4-dimethylenepyrrolidyl) arylenes and bismaleimides yields aromatic polyimides. This monomer system is very reactive; thus, making purification and storage difficult. The polymers prepared from this system are soluble only in concentrated sulfuric acid. In order to reduce the reactivity of this bis(exocyclicdiene), one of the pyrrolidyl ring bonds holding the diene in the reactive s-cis configuration was eliminated. This was achieved by the synthesis of bis(N-isoprenyl) tertiary aromatic amines. These monomers were observed to be less reactive thus allowing for their purification and storage. However, polymers prepared from this monomer system were of low molecular weight. To increase the reactivity of the bis(isoprenyl) monomer, steric bulk was introduced in the ortho positions to the amine functionality. This was accomplished by the synthesis of 1,4 -N,N'-diisoprenyl-2,3,5,6-tetramethyl benzene. Results from the  $\eta_{inh}$  data indicate that this monomer series was more reactive than those previously reported. However, this polymer is easily oxidized as evident by the TGA data in air. This oxidation may be occurring at the secondary amine site. Amidation of the bis(isoprenyl) secondary amine monomers was expected to eliminate the easily oxidized amine group and to further increase the reactivity of the bis(isoprenyl) monomer. Molecular models suggest that the steric effects of the amide should make the s-cis configuration of the diene more favorable.

THE SYNTHESIS OF POLY(AMINE IMIDES) UTILIZING THE DIELS-ALDER REACTION. Raphael M. Ottenbrite and Joseph G. Smith Jr.\*, Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia 23284

The Diels-Alder preparation of polyimides from substituted bis (N-phenyl-3,4-dimethylene pyrrolidyl) monomers has been previously reported. This bis(exocyclicdiene) when reacted with bismaleimides affords an insoluble polymer without the evolution of gaseous byproducts. The polyimides prepared from this system exhibited no weight loss up to 300 C. A problem with this bis(exocyclicdiene) monomer is that it proved to be too reactive, thus making it difficult to purify.

To reduce the diene reactivity it was proposed to open the pyrrolidyl ring holding the diene in the s-cis configuration. Molecular models reveal that the diene could exist in both the s-cis and the nonreactive s-trans configurations which should modify the reactivity. Model compounds show that this monomer does undergo a Diels-Alder reaction with bismaleimides to afford the polyimide structure. The objective of this research is to prepare polyimides by the Diels-Alder process which will retain their toughness and integrity during long exposure times at elevated temperatures.



**SYNTHESIS OF POTENTIAL POLYMERIC DRUG CARRIERS.** Raphael M. Ottenbrite and Stephen C. Thompson\*, Dept. of Chem., Va. Commonwealth Univ. Copolymers of maleic anhydride with monomers that contain an active ester functionality offer the possibility of being versatile polymeric drug carriers. These copolymers have characteristics that are common to polymeric drug carriers. Incorporated into the copolymer is a method for the control of solubility, and a site at which compounds, such as drugs, directing groups, or tags, may be attached. The solubility of the copolymers can be controlled by modifying the anhydride functionality. Base hydrolysis to the carboxylate salts produces the hydrophilic copolymer while esterification with various aliphatic alcohols produces copolymers that are more hydrophobic in nature. The active ester provides the site of attachment for various compounds. The purpose of this research is to prepare the copolymers of maleic anhydride with monomers that have an active ester functionality and to evaluate their potential as polymeric drug carriers.

**ENZYMATIC MOBILIZATION OF FERRITIN IRON.** Kenneth Pearce and Richard W. Topham, Dept. of Chem., Univ. of Richmond, Richmond, VA 23173. Two liver enzymes, xanthine oxidoreductase and a NADH-FMN oxidoreductase, have been proposed to catalyze the reductive release of iron from ferritin. The abilities of xanthine and NADH to serve as a source of reducing power for this process were compared with turkey and rat liver homogenates. Saturation kinetics were observed with both substrates. A comparison of the ratio of  $V_{\max}/K_m$  suggested that xanthine was more efficient. The presence of a flavin nucleotide in the assay was essential for ferritin-iron release with both substrates. NADPH was substituted for NADH with no loss of activity. Dicumarol did not inhibit ferritin-iron release with NADH or NADPH demonstrating that the enzyme responsible for this activity is not liver "DT-diaphorase." Allopurinol completely inhibited the activity with xanthine but did not affect the activity with NADH or NADPH. Allopurinol also inhibited the activity endogenous to liver homogenates prior to dialysis. These results suggest that xanthine, NADH, and NADPH could serve as a source of reducing power for the enzyme-mediated reduction of ferritin iron with a flavin nucleotide serving as an electron shuttle to the iron in the ferritin core. (Supported by NIE Grants M 36737 and DK 38313).

**NEW NICOTINOYL ALKALOIDS FROM *MAYTENUS* SPECIES.** Kumar Sekar, John A. Suchocki, and Albert T. Sneden, Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia 23284-2006.

The Celastraceae family of plants is known for the diverse classes of compounds present as secondary metabolites in different species. Triterpenes, alkaloids, and maytansinoids have all been isolated in our group in the past ten years from plants in this family. Recent investigations of *Maytenus rothiana*, a Celastraceae plant from India, led to both maytansinoids and three new nicotinoyl alkaloids. These alkaloids proved to be related to evonine, a sesquiterpene nicotinoyl alkaloid isolated from another Celastraceae genus, but were found to be somewhat more complex. The structures of these alkaloids were established by high field NMR and mass spectral data. These data indicated that the three alkaloids are homologues which differ in the structure of the C-5 ester moiety. This work has renewed the interest in novel alkaloids in our group. Current efforts directed toward the isolation and characterization of the alkaloids of *Uncaria guianensis* (Rubiaceae), a medicinal plant from Peru, will also be discussed.

(Supported in part by a grant from the Horsley Cancer Fund of the Virginia Academy of Science.)



RESONANCE RAMAN INVESTIGATION OF PEROXIDASE REACTION INTERMEDIATES. John R. Shiffllett and James Turner\*, Dept. of Chem., Va. Commonwealth Univ., Richmond, Va., 23284. Peroxidases are heme proteins that possess the ability to oxidize substrates using  $H_2O_2$  and other organic peroxides. This catalytic cycle proceeds through two intermediate forms of the resting enzyme. These transient species are known as compounds I and II and differ in oxidation state but resemble one another in that both are believed to contain an oxo-ferryl group at the active site. This laboratory has previously reported the observation of the oxo-ferryl vibration of Horseradish peroxidase compound II. This low frequency band is complemented by high frequency vibrational shifts resulting from structural changes as the enzyme transforms from native protein (five coordinate, high-spin) to compound II (six coordinate, low-spin). Another peroxidase heme protein known to form compound II in its catalytic cycle is Chloroperoxidase; however, no resonance Raman spectra have been reported. Studies undertaken in this laboratory have obtained spectra from the high frequency region for compound II of Chloroperoxidase. This data strongly resembles published spectra for the high frequency region of ferryl myoglobin, which contains an oxo-ferryl group.

SYNTHETIC LUBRICANTS: A DEUTERIATION STUDY. Wayne M. Stalick and George W. Mushrush, Chemistry Department, George Mason University, Fairfax, VA 22030

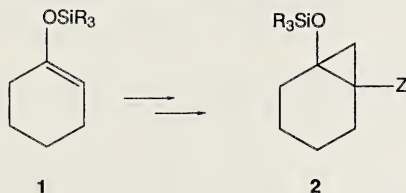
The development of lubricants has closely paralleled the development of engines. Early saturated hydrocarbon oils were satisfactory for automobiles but with the development of the jet engine, wide temperature range synthetic lubricants became a necessity. The production of new high technology engines and machines is currently being limited until the development of even better specialized high temperature lubricants. To this end, studies have been initiated on perdeuterated polyol esters which show great promise as a possible new generation of lubricants. The results of bearing tests which were run over a wider range of temperatures and under more stringent specifications than with previous lubricants, in addition to tests of oxidative stability, emphasize the value of continued research in deuterated lubricants. The current study looks at the problems of synthesizing these compounds on a large scale and presents a series of promising reactions that can be used to accomplish the task.

DISTRIBUTION OF TRACE METALS IN SOILS AND SEDIMENTS. I. T. Urasa and W. J. Mavura, Department of Chemistry, Hampton University, Hampton, VA 23668. Trace metals can exist in soils and sediments in different oxidation states as water-soluble as well as water-insoluble species. The distribution of these species can be accurately assessed only if an analytical approach is used that has the capability to provide quantitative information on the various species present separately, and also the total concentration of the metal present. This paper discusses some methods developed to determine the distribution of selected trace metals in soils and sediments by using a combination of chromatographic and spectroscopic techniques. The results obtained indicate that water soluble species of iron and chromium can be determined at sub-microgram per gram level. Sandy soils and sediments have relatively less soluble and insoluble iron and chromium than clay types. Sludge and other fertilizers have a direct effect on the solubilization of trace metal species.

BICYCLIC ORGANIC CARBENE REACTIONS. George S. Whitney, Clifford Deal and Susan E. Bienert. Dept. of Chem. Washington and Lee University. Lexington, VA 24450. We have been working on the decomposition of toluenesulfonylhydrazones in bases, varying them to see if it will change the composition of products in the classic camphor series. Shapiro found that bornene was formed with alkyl lithiums. Camphene forms predominately if the solvent is protic, tricyclene predominates with aprotic solvents. We've extended the array of bases studied to dimsyl sodium ( $CH_3SOCH_2Na$ ), and now to water free  $K_2CO_3$  using a phase transfer reagent.

SILYLENOLETHERS AS A ROUTE TO FUNCTIONALIZED CYCLOPROPANES. Charles Wilkins and Suzanne M. Ruder, Department of Chemistry, Virginia Commonwealth University, Richmond, VA 23284-2006.

Silylenolethers **1** are readily prepared and can be utilized in the preparation of  $\beta$ -substituted silyloxycyclopropyl derivatives **2**. These compounds are of interest for further studies of ring expansion reactions involving strained ring systems.



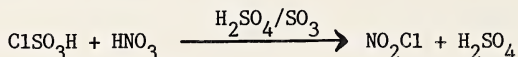
IN SEARCH OF THE POSSIBLE TOXINS ASSOCIATED WITH OPSANUS TAU (THE OYSTER TOAD FISH). R. L. Williams and Miki Taria, Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508. Opsanus Tau (O. Tau), better known as the oyster toad fish has been considered to possess some toxic component perhaps related to a defense mechanism. Our studies have revealed that the spines of the O. Tau do not possess any obvious toxin; however, 3-octanone has been reported to be found in the slime of this fish and does produce certain neurotoxic effects. We wish to present a scenario which proposes that the O. Tau may in fact produce and secrete a novel cholinergic toxin related to that observed in the Hawaiian box fish. A structural and chemical relationship will be described to link the 3-octanone to this novel cholinergic agent.

7,7'-DIPYRIDYL-TETRAHYDROIMIDAZO-(3,4-b) PYRIDINE: A POTENTIAL GAMA AMINO BUTYRIC ACID (GABA) ANTAGONIST. R. L. Williams and Tricia Tosi, Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508. Over the past five years this laboratory has sought to determine the nature and etiology of the phenomena known as Explosive Motor Behavior (EMB). First observed by icv injection of morphine into the substantia nigra of the rat brain, this episode can be reproduced with a variety of organic agents including the title compound. We now wish to redefine the EMB as a selective convulsive episode that can be elicited by various gamma amino butyric acid (GABA) antagonists. The tetrahydroimidazo-(3,4-b) pyridine ring system has now been established as a potent GABA-B antagonist. The evaluation and characterization of this new GABA-B antagonist will be discussed.

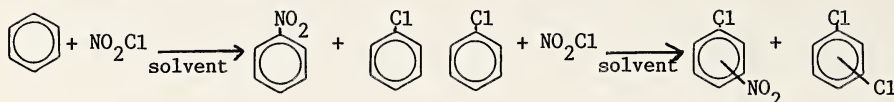
5-PHENYLOXAZOLIDINES AS POTENTIAL CARDIOVASCULAR DRUGS. R. L. Williams and Tammy Wang, Department of Chemical Sciences, Old Dominion University, Norfolk, VA 23508. We wish to describe the synthesis and evaluation of a new cardiovascular agent, 5-(4-hydroxyphenyl)-2-spirocyclohexano-oxazolidine. This new drug can be considered a potential new inotropic agent in that it causes a significant increase in both the heart rate and blood pressure in test animals. The synthesis, evaluation and further mechanistic characterization of this new agent will be discussed.

## NITRYL CHLORIDE AS AN AROMATIC NITRATING AGENT IN CHLOROALUMINATE MELTS.

Anthony Osei Wusu\*, Unchu Ko\*, and Charles M. Bump, Department of Chemistry, Hampton University, Hampton, VA 23668. Nitryl Chloride, a highly volatile gas has been prepared by a slow addition of chlorosulfuric acid to nitric acid in the presence of sulfuric acid and used in the electrophilic nitration of benzene and chlorobenzene with aluminum chloride/1-methyl-3-ethyl imidazolium chloride as solvent/catalyst



Two separate reactions carried out revealed that in addition to the nitration reactions, chlorination of the aromatic substrates occurred.



THERMODYNAMIC AND KINETIC STUDIES OF CYTOCHROME C FROM DIFFERENT VERTEBRATE SPECIES. Xiaoling Yuan and Fred M. Hawkrige, Dept. of Chem., Va. Commonwealth Univ., Richmond, Va. 23284. Conformational changes that occur when cytochrome c transfers electrons may control rates of electron transfer in vivo. The temperature dependence of the formal potential and the heterogeneous electron transfer rate constant for horse heart cytochrome c was studied previously under conditions of different anion binding. Maximum electron transfer rates occurred at different temperatures but at the same formal potential. Certain conformations of the two redox forms of cytochrome c appear to result in the maximum rates of electron transfer. In this work, cytochromes from sources with a range of normal body temperature and known similarities and differences in amino acid sequence have been chosen for study. Sample sources and normal body temperatures in degrees Centigrade include: horse (38°C), pigeon (43°C) and Tuna (variable). The results of electrochemical studies of these cytochromes will be presented.

## Education

CHAOS AND THE UNDERGRADUATE CURRICULUM. Steven G. Desjardins, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. The structure and success of a recently completed course on chaos and nonlinear dynamics will be discussed. Since these theories only allow for statistical prediction, some elements of statistical thermodynamics are also introduced. This course was offered at the introductory level with no prerequisites, so that the class was a mixture of science and non-science majors. Emphasis is placed on using computer graphics as a mathematical tool as well as the usefulness of a general dynamics course as interdisciplinary science. Student reactions will also be presented.



CRITICAL THINKING: AN INTER-DISCIPLINARY, INTER-INSTITUTIONAL MODEL OF ACTION. Bernard H. Levin, Blue Ridge Comnty. Col., Weyers Cave, Va.

24486. This paper discusses some recent trends and the current zeitgeist in education. Critical thinking is described as a movement secondary to changes in societal perception. A brief overview of one model of conceptualization, implementation, and assessment of critical thinking at the intercollege, interdisciplinary, and intracourse levels is presented. Some implications for social systems and for student learning are explicated.

TRAINING SUPERVISORS: AN IMPROVED APPROACH TO AN OLD PROBLEM. Bernard H. Levin, Blue Ridge Comnty. Col., Weyers Cave, Va. 24486 & Marta Keane, InSpeech, Inc., Fort Washington, Pa. Supervisory training materials focus almost exclusively on the normal corporate environment, although when the environment is normal, supervisors are seldom at risk. Supervisors in the field should be prepared to prevent and to cope constructively with a hostile social environment. This paper provides some suggestions.

FACTORS INFLUENCING THE ALTERNATIVE SCIENCE CONCEPTIONS OF PRESERVICE TEACHERS. George E. Glasson and Thomas G. Teates, Div. of Curriculum and Instruction, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061. This study investigated the variance attributable to formal reasoning ability and experience in university level science courses in relation to predicting preservice teachers' knowledge of selected physical science concepts. The Test of Alternative Science Conceptions (TASC), developed by the researchers, revealed differences in the physical science knowledge domains of 155 preservice teachers enrolled in elementary and secondary science methods classes. The Test of Logical Thinking (TOLT) was used to assess the formal reasoning ability and a survey was used to assess the content background of preservice teachers in the subjects of biology, physics, chemistry, geology, and astronomy. A stepwise multiple regression analysis revealed that formal reasoning ability and the number of courses in physics and chemistry at the university level accounted for thirty-nine percent of the variance on the TASC instrument. Teacher conceptions were clarified by interviewing selected subjects as they responded to test items.

LABORATORY LEARNING IN SCIENCE. THOMAS G. TEATES, Div. of Curriculum and Instruction, Va. Polytechnic Inst. and State Univ., Blacksburg, VA 24061. The role of the lab. in school science programs has been examined and characterized in descriptive terms. The strengths and weaknesses of lab. centered science courses have been examined from teachers' and students' perspectives. There continues to be a dearth of research data or conclusive evidence to justify the relatively expensive and time consuming lab. experiences. An extensive qualitative research study of the lab. portion of a one-semester chemistry course for a group of gifted students was conducted in the spring of 1989. Preliminary analyses of the video and audio tapes, student and teacher interviews, and field notes indicate that students value the lab. as place to "see science happen," not just read about it. They see it as adding variety and interest to the class and providing an opportunity to learn safe procedures. There appear to be some unique and effective learning opportunities afforded by lab. study. Data analyses continue.

MOLECULES IN CLASS: SHOWING YOUR STUDENTS HOW TO DRAW SUGARS. George S. Whitney, Dept. of Chem., Washington and Lee Univ., Lexington, VA 24450. Glucose, perhaps the most successful molecule in nature has been drawn early, often and in many ways. Polymerized, it stores energy as starch, or holds up trees as cellulose. Central to metabolism in cells, glucose continues to appear in even graduate and medical texts as a straight stick, or in the Haworth form. We can teach our students at the undergraduate level (or high school?) to draw and therefore THINK ABOUT a stereochemically correct chair form. We think this enhances their biochemical understanding and actually reduces the need to memorize. The step-by-step process begins with a backwards Z and extends its bottom line (omitting a middle third.) Then a series of parallel lines finish this all-equatorial chair form. Students with little practice produce a surprisingly good structure, in short time.

## Engineering (*No Abstracts Submitted*)

## Environmental Science

DYNAMICS OF NATIVE BROOK TROUT IN THE HAZEL RIVER, SHENANDOAH NATIONAL PARK. Roger D. Bryan and John J. Ney\*. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061. The longitudinal distribution and seasonal dynamics of southern Appalachian brook trout populations are poorly described. This study examines native brook trout abundance at three sites in the Hazel River. Density and standing stock of brook trout decreased in a downstream direction. The headwater area appears to serve as a nursery location to colonize downstream sites. Brook trout were virtually absent at the most downstream site. Between June and October, brook trout density declined more than 10% at all sites. Most of the over-summer decline occurred in adult (ages 2 and 3) fish. The distributional and temporal dynamics of brook trout in the Hazel River appear to be governed by a complex of factors including environmental stress and predation.

ASSESSING PUBLIC AND PROFESSIONAL KNOWLEDGE OF LAND USE IMPACTS ON COLDWATER ECOSYSTEMS USING THE DELPHI METHOD. Sheryl A. Bryan and Larry A. Nielsen. Dept. of Fisheries and Wildlife Sciences, Va. Polytech. Inst. and State Univ., Blacksburg, Va. 24061. Watersheds are the integration of land and water resources. Activities such as timber harvest, road and railroad construction, urban development, recreation, and industry alter these areas, causing changes in coldwater stream quality within the watershed. Land use affects several parameters of water quality that are critical to the maintainence of healthy salmonid populations (e.g.- water temperature, dissolved oxygen, sedimentation). The combination of complex watershed interactions, differing user group objectives, and interactions between the user groups makes managing the system difficult. To effectively manage the system, an accurate assessment of public and professional knowledge and ideas is needed. The Delphi Method is directed at the systematic solicitation of group opinion. Presented as a series of iterative questionnaires, the Delphi Method generates a group consensus which accurately reflects the knowledge of the groups. The application of the Delphi Method to fisheries science strengthens public involvement in the decision making process, a vital part of effective management programs.



ENVIRONMENTAL COMPARISON OF NATURAL AND MAN-MADE SALTMARSH IN NORFOLK, VA. D. Feigenbaum\*, D. Swift\*, C. Blair, Old Dominion Univ., Norfolk 23508; W. Priest, VIMS; M. Bushing\*, VMRC. In 1983-4 a wetland on Willoughby Bay was filled and a new marsh (Monkey Bottom) created about 1000 meters north. In 1988 we compared certain characteristics of the new Monkey Bottom marsh with those of existing natural marshes in the Lafayette River. Marsh plants at Monkey Bottom were slightly more productive and denser than at the Lafayette. Excluding nematodes (the most numerous organisms at the Lafayette site,) Monkey Bottom samplings contained more benthic invertebrates than Lafayette. Menhaden, silversides, and mummichogs were taken in net samples at both locations. There was little significant difference in bird population densities and species assemblages. The new marsh had accumulated an average of 4 cm of sandy sediment resting on compacted, finer grained old marsh deposits. We concluded that in four years Monkey Bottom, because of its design, location, and construction, had roughly compensated for the loss of the old marsh. (Supported by NOAA, VA Council on the Environment, City of Norfolk.)

LIFE HISTORY OF THE ENDANGERED JAMES RIVER SPINY MUSSEL, (PLEUROBEMA COLLINA). Mark C. Hove, & Richard J. Neves, Dept. of Fisheries and Wildlife Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Aspects of the life history of the James River spiny mussel, to include gravidity and glochidial release periods, fish host requirements, and age characteristics, were studied in tributaries of the upper James River drainage from May 1988 through February 1989. Female mussels were gravid from late spring through early summer. In the Potts Creek drainage glochidia were released from late June through early July, at mean water temperatures between 21.5-24.5°C and water flow between 1 and 2 ft<sup>3</sup>/sec. Five fish families (14 species) were tested for suitability as fish hosts, but only minnows (8 species) served as hosts for glochidia. Median age of shells, collected from muskrat middens and cross-sectioned with a diamond-studded saw blade, was 8 years, with a maximum age of 19 years. The mean annual mortality rate was 12.4%. (Supported by the North Carolina Wildlife Resources Commission and the U.S. Fish and Wildlife Service.)

GROWTH OF CENTRARCHID FISHES IN THE JAMES RIVER: A PRELIMINARY REPORT. Mark A. King & Greg C. Garman, Dept. of Biol., Va. Commonwealth Univ., Richmond VA 23284. Centrarchids from James River, Va., from Eagle Rock to Richmond were aged by scale annuli. Annuli on sectioned sagittal otoliths of two species, smallmouth bass and redbreast sunfish, confirmed scale ages for age-1 to age-4 but scales underestimated ages of smallmouth bass greater than age-4. One individual smallmouth bass of age-13 may represent the oldest reported from a southeastern river. Back-calculated length-at-age for smallmouth bass of age-1 to -4 was greatest at lower Piedmont province stations when compared to upper Piedmont and to Valley and Ridge. Trophy-sized smallmouth bass of age-5 and older also grew faster in the lower Piedmont where they reached weight 1.8 kg (4 lbs) in year-7 of life, whereas this weight was attained in year-10 for Valley and Ridge samples. Lengths of redbreast sunfish were equivalent at lower Piedmont and Valley and Ridge stations, and were somewhat shorter at upper Piedmont stations. Bluegill length-at-age was also greater in lower Piedmont samples compared to upper Piedmont for age-1 and age-2, but for age-3 and age-4 lengths were equivalent in these two regions. Rockbass length-at-age was similar at the two Valley and Ridge stations.



THE USE OF MITOCHONDRIAL DNA ANALYSIS TO EVALUATE GENETIC DIFFERENCES IN SMALLMOUTH BASS (MICROPTERUS DOLOMIEUI) FROM THE JAMES RIVER, VIRGINIA. John A. Snyder, Dept. of Biol., Va. Commonwealth Univ., Richmond, Va. 23284, & G. C. Garman, Dept of Biol., Va. Commonwealth Univ., & R. W. Chapman \*, Johns Hopkins University-Chesapeake Bay Inst. Shady Side, Md. 20764. Smallmouth bass (M. dolomieu) were taken from seven sites on the mainstem James River, ranging from near the headwaters to the fall line at Richmond. Mitochondrial DNA was extracted from liver and ovary tissue and restriction endonucleases were used to determine if any genetic heterogeneity was present. One hundred and seven specimens were assayed with seven different endonucleases and only three distinct composite genotypes were identified. Two of these genotypes were represented by only one individual each. Individual fish from six other Virginia drainages were similarly analyzed and some drainages showed slightly higher levels of variation. Eight fish from Missouri taken from a drainage where smallmouth bass are native showed much greater diversity-three genotypes were identified represented by two, three, and three individuals, respectively.

## Geology

PROGRESS IN COMPUTER MODELING OF POLYCRYSTALLINE FABRICS IN ROCKS, Robert Bunting and Roddy V. Amenta, Dept. of Geol. and Geog., James Madison Univ., Harrisonburg, Va. 22807. The computer simulation of fabrics in polycrystalline solids such as rocks, metals, ceramics, or composite materials holds promise for new types of experiments in predicting the bulk properties of such solids. Our previous model dealt with growth of a single crystal by accretion of mass proportional to its unit cell volume. A recent model deals with growth of multiple crystals each according to their own lattice geometries. Since the large database generated by this model requires more memory than is available in computer RAM, a virtual memory management system was designed and incorporated in the model. Such a system permits the hard disk to be used as a logical extension of RAM. A major problem yet to be resolved is the need for arbitration among growing crystals competing for limited space.

PETROGRAPHY OF OPALIZED PLANT REMAINS IN POTTERY FROM ST. EUSTATIUS. Stephen C. Clement, Dept. of Geology, College of William and Mary, Williamsburg, VA 23185 and C. J. Bell, Dept. of Quaternary Studies, Northern Arizona Univ., Flagstaff, AZ 86011. The majority of nineteenth century earthenware pottery fragments from Saint Eustatius, one of the Leeward Islands of the Lesser Antilles, contain the igneous minerals and igneous rock fragments expected on an island formed of pyroxene andesite, hornblende andesite, dacite, andesitic basalt, scoria and tuffs. In a small group of shards, silicified woody or plant material was used as temper rather than igneous material. Although silicification has preserved the cell structure well, not enough detail remains for a positive botanical classification. The fragments most likely are from a herbaceous plant. Tracheids are filled by precious opal whereas the ray cells are empty suggesting that the plant may have been buried alive by pyroclastic material. Fluids containing dissolved silica entered the tracheid system but were excluded from the ray cells containing protoplasm.

FLUVIAL TERRACE DEVELOPMENT IN THE NORTH RIVER BASIN, ROCKINGHAM COUNTY, VIRGINIA. L. S. Eaton\* and W. C. Sherwood, Dept. of Geol. & Geog., James Madison University, Harrisonburg, Va. 22807. North River rises in the sandstone capped ridges west of the Shenandoah Valley and flows southeastward over valley shales and carbonates. Along the western edge of the valley the river and its western tributaries have deposited extensive coarse grained alluvial aprons over the valley carbonates. The aprons give way to a well developed system of terraces as distance from the clastic source increases. Generally terrace morphology is best preserved over shale bedrock and more irregular over carbonate bedrock. An excavation in the lowermost terrace (T1) near Bridge-water Airport was studied in the field and sampled for laboratory analyses. Conclusions resulting from these investigations are: 1) the river is actively downcutting and migrating northward producing a series of five well defined terraces on the south bank, 2) thickness of alluvium at this site is 3.5 meters, 3) five depositional units ranging in texture from coarse gravel to loam were recognized, 4) textural determinations showed a general fining upward in the sequence, 5) overbank deposition was the dominate mechanism of sedimentation.

#### THE GEOLOGY OF RADON HAZARD IN VIRGINIA

\*R.G. Goodell, Dept. Environmental Sciences, University of Virginia, Charlottesville, VA 22903

Radon (Rn 222) gas and its radioactive daughters, generated by the radioactive decay of uranium (U-238), have been identified as significant long-term health risks in the indoor air of some buildings constructed on soils derived from uranium bearing bedrock. The USEPA advises mitigation to reduce radon concentrations to below 4 picocuries per liter of indoor air. Data from commercial testing firms which use long term alpha track detectors have provided 8200 measurements of radon in Virginia homes by zipcode. When these are plotted the geologic map of Virginia emerges. In the coastal plain the probability of a house exceeding 4 pCi/l is less than 10% and decreases toward the coast. In the piedmont that probability is 30% with local values in excess of 50% in houses located on dark gray phyllites, graphite schists, slates and hornfels. Homes located in the Triassic Basins have radon values equivalent to the rest of the piedmont. The highest probabilities of radon exceeding 4 pCi/l occur in the Valley where they average 50%, with values exceeding 70% in houses located on black or dark gray shales. Virginia geology appears to accurately predict radon hazard.

TRANSPRESSIONAL DEFORMATION ALONG THE RUSSELL FORK FAULT, HAYSI QUADRANGLE, VA. William S. Henika and Jan P. Zentmeyer, Va. Dept. of Mines, Minerals and Energy, Big Stone Gap, Va., 24219. Most younger students of Appalachian structural geology would probably think of the Russell Fork fault as a simple "tear fault" that formed the northeast boundary of the Cumberland overthrust block of far southwestern Va. This may be the result of the emphasis placed on simple strike slip displacement along the Russell Fork fault by J. L. Rich, in his now famous thin-skinned model (1934), and by later workers lacking first-hand experience with the structures measured in the field by Wentworth, who mapped the fault in 1921 for the Va. Geological Survey. Wentworth not only delineated the sequential development of the bounding faults (of the Cumberland block), but also documented early oblique divergence and later oblique convergence (transtension, then transpression) across the fault. Recent detailed mapping, subsurface stratigraphic and structural studies, as well as detailed structural analysis of folds, kink planes, and minor faults have reconfirmed Wentworth's original interpretations. A computer contoured structure map shows only 1 kilometer of right lateral slip and calculated displacement vectors supporting oblique movement are much more common than those indicating simple strike slip along the Russell Fork fault.



GEOLOGY OF THE POCAHONTAS NO. 3 COAL BED IN CENTRAL BUCHANAN COUNTY, VIRGINIA. Jack E. Nolde, Va. Div. of Mineral Resources, Abingdon, Virginia 24210.

The Pocahontas No. 3 coal bed ranges in thickness from 1 to 5 feet and is continuous over 120 square miles of central Buchanan County. Of original resources exceeding 687 million tons, 483 million tons (more than 42 inches thick) remain. Estimated total natural gas in place in the Pocahontas No. 3 is nearly 218 billion cubic feet.

Fitting trend surfaces to coal thickness and structural contour data permits interpretation of depositional environments and recognition of areas of gas accumulation. The pattern of positive residuals from a third order trend-surface shows that early low relief structural features, existing during or soon after peat deposition, exerted a major influence on the location of gas accumulation.

The Pocahontas No. 3 coal, the overlying sandstone, and the lateral equivalents of both were deposited in a delta plain and barrier bar setting. The peat that formed the coal was deposited in a swamp confined by levees. The overlying sandstone is comprised of a micaceous sandstone deposited across the swamp as a channel fill or crevasse splay and a quartzarenite which formed barrier bars.

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GEOLOGY FOR HOMEOWNERS James V. O'Connor, Dept. of Env. Sci., MB 44-04 Univ. of D.C., Washington, D.C. 20008-1154.

This model program is a two-hour workshop for the public. The keys to this program are the availability of free county geomaps and a quick but enjoyable method to understand foundation conditions fundamental to ensuring a quality investment in a home. The content focuses on teaching basic map interpretation skills in half-hour segments. Topographic, geologic, soil, and drainage basin maps from a county are the texts. Unit one involves reading contours and valleys deciphering grid systems, and preparing a slope map. In unit two participants decipher and color a county geologic map for interpretation of original environments, geologic history, and geohazards associated with each rock unit. Unit three includes an analysis of a soil map for slopes and symbol meanings, and comparison of a site core to the soil map, soil survey, and textural triangle. In unit four studies of flow behavior in a neighborhood from a county drainage basin map center on the type and size of drainage basins, tracing local stream networks and water pipelines, and groundwater-sheds.

PIEDMONT AND COASTAL PLAIN SOIL STUDIES IN VIRGINIA, Robert J. Pavich, U. S. Geological Survey, Reston, VA 22092. Virginia offers the opportunity to study many soil types on different parent materials. Contrasts of Piedmont and Coastal Plain soils provide geologic information about the surficial processes affecting the geomorphic histories of those two provinces. Piedmont regolith is comprised of average thickness of 15 m of saprolite and 80 cm of soil. These form in place beneath Piedmont upland drainage divides. Saprolite is the isovolumetric product of rock weathering, and soil forms through alteration of saprolite by mechanical and geochemical processes. Upland represents about 1/4 of the original saprolite after volumetric reduction and chemical mass loss. Comparison of Piedmont soils with soils on dated Coastal Plain terraces, rate of topographic inversion, and inventories of cosmogenic  $^{10}\text{Be}$  all indicate that the average Piedmont upland soil is produced and eroded in about  $10^6$  years. The continued production and removal of Piedmont regolith is a significant concept in a model of the physiographic evolution of the Appalachian Piedmont province.



EVOLUTION OF FLUVIAL STYLES IN THE EARLY MESOZOIC CULPEPER BASIN. Joseph P. Smoot, U.S. Geological Survey, M.S. 926, Reston, VA. 22092. Preliminary analysis of the Late Triassic fluvial deposits of the Culpeper basin indicates a change in depositional character as the basin developed. Basal conglomerates of the Manassas Sandstone containing clasts mostly derived from the immediately adjacent bedrock form the unconformable eastern margin of the basin. They reflect deposition by small streams and accumulation as colluvium on an irregular topography. These deposits are abruptly overlain by cross-bedded quartz pebble conglomerates and sandstones, deposits of large braided rivers. The radical change in fluvial style and provenance suggests a regionally unconformable contact with the underlying conglomerates. Arkosic sandstones of the upper Manassas and lower Balls Bluff Siltstone are deposits of muddy meandering rivers that are progressively finer grained upsection, suggesting a progressive decrease of stream gradient. These meandering river deposits are, in part, coeval with alluvial fan conglomerates along the western border fault and with cyclic lacustrine deposits to the south, suggesting change to an axial river system as faulting formed a closed basin. Cross-bedded conglomerates and sandstones of the Catharpin Creek Formation are braided river deposits that may represent progradation of an axial terminal fan at the end of the Triassic.

EXAMPLES OF HIGHWAY LANDSLIDES IN VIRGINIA. Chester F. Watts\* & Robert C. Whisonant, Inst. for Engineering Geosciences, Dept. of Geol., Radford University, Radford, Va. 24142. Analysis of three selected unstable highway road cuts in Virginia illustrates the diversity of geologic problems faced by the Commonwealth's road builders. The first cut is along U.S. 460 near Cedar Bluff, Tazewell County, in the Valley and Ridge Province. The rocks exposed are primarily Cambrian carbonates forming the leading edge of the St. Clair thrust sheet. Intersecting discontinuities have caused a number of rockfalls and wedge failures. The second cut is also a Valley and Ridge exposure; it is along State Route 259 at Brocks Gap, Rockingham County. Highly fractured Ordovician-Silurian sandstones contain two major joint sets which daylight along the cut. Rockfalls and rock slides are the principal means of movement along these surfaces. The final cut is in the Blue Ridge along I-64 at Afton Mountain. Exposed here is the Catoclin Formation (Late Proterozoic) composed of metabasalts with interbedded slates and phyllites. The most troublesome movement here is debris sliding of colluvium along weathered metashales. This local failure is actually part of a much larger and older landslide mass developed on the southern flank of Afton Mountain.

CONTRASTING SEISMIC RESPONSES TO LUNAR GRAVITY IN EASTERN AND WESTERN VIRGINIA. Robert E. Weems, MS 928, U.S. Geological Survey, Reston, VA 22092, and William H. Perry, Jr., Booz, Allen and Hamilton Inc., 4330 East West Highway, Bethesda, MD 20814.

Timings of earthquakes in the central Virginia and Giles County Bollinger seismic zones indicate distinctly different responses to lunar gravity. The central Virginia zone shows a strong diurnal tidal response when solar declinations are within  $17^{\circ}$  of the equator, a strong tendency for earthquakes to occur in the winter when lunar declinations are negative, and a strong tendency for earthquakes to occur when the moon is in the eastern sky and solar declinations are more than  $17^{\circ}$  from the equator. In the Giles County zone, the diurnal tidal effect is weak or lacking, and lunar declination does not seem to affect seismicity. Earthquakes are most common when the moon is in the eastern sky and solar declination is more than  $10^{\circ}$  from the equator. These contrasts in seismic response suggest that these two seismic zones are controlled by different tectonic processes.

EXPOSED AND INFERRED EARLY MESOZOIC BASINS ONSHORE AND OFFSHORE VIRGINIA. G.P. Wilkes, S. S. Johnson, and R. C. Milici, Va. Div. of Mineral Resources, Box 3667, Charlottesville, Va. 22903. In Virginia, the Atlantic Coast rift system of early Mesozoic age is exposed in the Piedmont and concealed beneath the Coastal Plain. All of the exposed basins are generally parallel with the regional trend of the Appalachian orogen. The areal extent of basins east of the Fall Line is not known in detail, but the approximate distribution of these buried basins has been deduced from drill holes supplemented by geophysical data. The exposed Richmond basin and the exposed part of the Taylorsville basin are on trend with drill holes in the Coastal Plain of Virginia and Maryland that have penetrated rocks of probable early Mesozoic age. This trend may be continuous into the Delmarva Peninsula as a belt of buried rift basins. Offshore Virginia rift basins have been identified on the basis of seismic reflection profiles. One of the identified basins is about 75 miles offshore of Southeast Virginia and is probably divided into two separate basins by a horst-like structure of basement rock.

## Materials Science

A STUDY OF IMPURITY DIFFUSION IN COBALT-COATED ALUMINA REINFORCED ALUMINUM METAL MATRIX COMPOSITES. T.D. Bayha and F.E. Wawner, Materials Science Department, Univ. of Virginia, Charlottesville, VA., 22901. Al-8Fe-4Ce P/M material reinforced with 20 % aluminum oxide fibers (Saffil) and cobalt-coated Saffil was tensile tested and studied under the scanning electron microscope. The presence of cobalt impurities introduced during processing was noted on fracture surfaces and a study of the relationship between high temperature exposure and size distribution of the particles was undertaken. It was found that the cobalt impurities coarsened with exposure to elevated temperatures at high rates while volume fraction of the particles remained essentially constant. A statistical analysis was performed on the size distribution data, and it was found that the particle size distribution changed with exposure to 500°C in a statistically significant manner.

THE CORROSION BEHAVIOR OF THE  $T_1$  ( $Al_2CuLi$ ) INTERMETALLIC COMPOUND IN AQUEOUS ENVIRONMENTS. R.G. Buchheit, G.E. Stoner, Center for Electrochemical Sciences and Engineering, Department of Materials Sciences, University of Virginia, Charlottesville, VA 22901.

The intermetallic compound  $T_1$  ( $Al_2CuLi$ ) is suspected to play an important role in the localized corrosion at subgrain boundaries in Al-Li-Cu alloys. The intermetallic was synthesized for characterization of its corrosion behavior. Experiments performed included open circuit potential measurements, potentiodynamic polarization and corrosion rate versus pH over the pH range of 3 to 11. Subgrain boundary pitting and continuous subgrain boundary corrosion are discussed in terms of the data obtained in these experiments. Evidence suggesting the dissolution and subsequent plating of copper on the alloy surface will also be presented.



POLYMERIC MATERIALS FOR SPACE APPLICATIONS, J. W. Connell, NASA Langley Research Center, Hampton, VA 23665-5225. High performance functional (films and coatings) and structural (adhesives and composite matrices) materials are needed for space applications. Organic polymeric materials offer many attractive properties such as; lightweight (low density), high strength, stiffness, dimensional stability and processability. However, the ability of these materials to maintain integrity and resist degradation during exposure to the harsh environment of space is questionable. Short term environmental durability (2-3 years) of some polymeric materials has been demonstrated in previous space applications. However, future spacecraft mission durations of 10-30 years require that the long term environmental stability of these materials be assessed. The key material needs, requirements and issues will be discussed.

FIGURE OF MERIT FOR Sb-Te P-TYPE ALLOYS. G.G. Day \*, B.R. Stoner \*, W.A. Jesser, F.D. Rosi \*, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901.

P-type material has been grown from the  $\text{Sb}_2\text{Te}_3$ - $\text{Bi}_2\text{Te}_3$ - $\text{Sb}_2\text{Se}_3$  alloy system by using a Horizontal Bridgman technique. The figure of merit for these alloys has been calculated from measurements of thermal conductivity, thermoelectric power, and electrical resistivity at 300 K. The processed ingots contained several regions with figures of merit between  $3.5 \times 10^{-3}$  and  $3.7 \times 10^{-3} \text{ deg}^{-1}$ . The processing parameters of growth rate and ingot diameter were also studied. Virtually no size effect on the figure of merit between 5 and 25mm diameters was observed, but increasing the growth rate increased the occurrence of multiple phase regions and as a result decreased the figure of merit. It should be noted that the multiple phase regions were seen in the last to freeze sections of all the ingots processed, regardless of growth rate.

DISLOCATION MORPHOLOGY AND CRITICAL THICKNESS OF EPITAXIAL GaAsP GROWTH ON GaAs BY MOCVD. Bradley A. Fox and William A. Jesser, Dept. of Materials Science, Univ. of Va., Charlottesville, VA 22901. Current critical thickness theories for lattice mismatched epitaxial growth consider only a single dislocation type. Zincblende crystals exhibit two distinct  $60^\circ$  dislocations, A(g) and B(g), which have different Peierls barriers to dislocation motion and exhibit asymmetric spacing along  $\langle 110 \rangle$  directions. Optical and transmission electron microscopy verify the existence of two critical thicknesses. Numerical calculations of the resolved shear stress on the eight slip systems rule out substrate misorientation as a source of the asymmetric dislocation spacing. Growth on a substrate rotated  $90^\circ$  proves the asymmetric dislocation density is due to different zincblende dislocation types. Etching in molten KOH yields rectangular etch pits defining the substrate orientation. The A(g) dislocations were found to be the easier misfit dislocation type to generate. This agrees with the lower Peierls barrier of A(g) dislocations found in n-type GaAs.



**ELECTROCHEMICAL VISUALIZATION OF CONVECTION IN LIQUID METAL,** James H. Hurst & Timothy J. Anderson, Department of Chemical Engineering, University of Florida, Gainesville, FL 32611 & Archibald L. Fripp, Jr. & William J. Debnam, Jr., Mail Stop 473, NASA Langley Research Center, Hampton, VA 23665. An electrochemical techniques for the visualization of buoyancy-driven convection in molten metals and semiconductors has been developed and tested. The experimental apparatus is designed to model the conditions in a Bridgman crystal growth furnace. Electrochemical cells employing the solid electrolyte yttria-stabilized zirconia are used to titrate and detect oxygen as a tracer element in the liquid. Tin is used as a model material for semiconductors such as lead tin telluride. Preliminary measurements of the activity and diffusivity of the tracer in the sample metal have been made. The mass transfer of the tracer element through the bulk sample under various temperature gradients has been measured and compared with the results of simple boundary layer and of finite difference computer models for natural convection in the sample material. The experimental results verify the validity of the computer model, and the computer model gives a detailed quantitative picture of fluid flow in the Bridgman sample.

**MATERIALS BY DESIGN,** P. Jena, Physics Department, VA Commonwealth University, Richmond, VA 23284. With the advancement in experimental techniques such as molecular beam epitaxy and out increased understanding of atomistic processes facilitated through theoretical studies involving high speed computers, it has become possible to produce new materials by controlling their size and environment. These man-made materials include clusters of atoms, and modulated structures. A glimpse of the rich physics and chemistry of these new materials and their dependencies on their size and composition will be given. The talk will concentrate on the equilibrium geometries of neutral clusters and the influence of ionizing radiation on their structural stability. The evolution of structural and electronic properties as clusters grow to become crystals will be discussed with a view to highlighting their quantum size effect. The potential for application of these materials in modern technology will be discussed.

**APPLICATION OF THE HANGING MENISCUS ROTATING DISK ELECTRODE METHOD TO OXYGEN REDUCTION ON PLATINUM IN  $H_3PO_4$ ,** Charles F. Kroen\*, Glenn E. Stoner, and S. Ray Taylor, Center for Electrochemical Sciences and Engineering, Department of Materials Science, University of Virginia, Charlottesville, VA 22901.

Results obtained using the hanging meniscus rotating disk electrode (HMRDE) method were compared with those using the standard RDE method for the oxygen reduction reaction on platinum in  $H_3PO_4$  at room temperature. Cyclic voltammograms and limiting current curves obtained from the HMRDE method were similar, but not identical, to those obtained from the standard method. A slight shape change was observed in the limiting current curves and non-linear Tafel plots were obtained for the HMRDE method. While the linear relationship between  $i_l$  and  $\omega^{1/2}$  described by the Levich equation was maintained, the slope was reduced and a small, positive intercept was present. Discrepancies between the two methods seem to be related to the different hydrodynamics involved with the hanging meniscus. In spite of the present discrepancies, the HMRDE method shows some promise for determining comparative kinetic information at elevated temperature (200°C).

COMPUTATION OF STRESS IN CRYSTALS DURING VERTICAL BRIDGMAN GROWTH, William R. Rosch, Material Science Department, University of Virginia, Charlottesville, VA & Frederick Carlson, MIE Department, Clarkson University, Potsdam, NY. A linear elastic, steady state, stress model has been developed to compute the stress field of crystals grown using the vertical Bridgman method. Numerically simulated boundary conditions were varied to find the impact on dislocation formation. The effect of the cold zone temperature, the insulation thickness, and the crystal sticking to the ampoule, were studied. Results show that stuck crystals have much more stress than unstuck crystals. The solid-liquid interface shape is a good indicator of the stress level, with negative interfaces having less stress. Finally, the average Von Mises isostress was found to be a linear function of temperature.

A STUDY OF THE EFFECTS OF HOT ROLLING ON DISCONTINUOUSLY REINFORCED AL ALLOYS. R. Schueller and F. Wawner, Materials Science Dept., Univ. of Virginia, Charlottesville, VA 22901, A sheet of rolled composite (SXA24E) was tensile tested and studied with the scanning electron microscope in both the as rolled form and after a T6 heat treatment. It was discovered that the composite was significantly weakened due to overaging of the matrix. This overaging is thought to occur during the cooling step after hot rolling. Large  $\theta$  phase precipitates (3-5 $\mu$ m) formed and weakened the composite. It was found that these precipitates are dissolved during the T6 heat treatment and the strength of the composite is regained.

It was also discovered that the precipitates were dissolved very quickly (< 1.5 minutes) and the strength regained. The very small grain size in the composite is thought to be responsible for this effect. Also, artificial aging of this composite was not necessary since it was found that short periods of room temperature aging gave results very similar to those of artificial aging.

SOLID-STATE ELECTROCHEMICAL STUDY OF THE LIQUID INDIUM-BISMUTH SYSTEM, Brian R. Sears & Timothy J. Anderson, Department of Chemical Engineering, University of Florida, Gainesville, FL 32611. The thermodynamic mixing properties of the molten In-Bi system were determined by using a solid-state electrochemical technique. Yttria-stabilized zirconia was employed as the electrolyte in the experiments. The activity of indium was measured as a function of composition and temperature, and the corresponding activity of bismuth was calculated through the Gibbs-Duhem equation. The activities of the components and the thermodynamic mixing properties of the alloys were compared to those obtained from previous investigations of the same system. The results obtained from this solid-state electrochemical study were found to be consistent with the results of the previous molten-salt electrochemical studies and vapor phase studies.



**APPLICATION OF MECHANICAL ALLOYING TECHNIQUES TO IMPROVE COMPOCAST COMPOSITES.** Shiao-Fong Yin and Frank Wawner, Materials Science Dept., Univ. of Virginia, Charlottesville, VA 22901. Limited damage tolerance and high cost limit the use of metal matrix composites in automotive powertrain components. Micron and submicron ceramic particulate reinforcement was targeted as having the potential to optimize high temperature strength and room temperature fracture toughness. Compocasting was chosen to produce the aluminum-based composite to minimize cost. Unfortunately, both the fabrication method and reinforcement size lead to an inhomogeneous dispersion and resulting poor mechanical properties. A unique solution is obtained by effecting a homogeneous dispersion of ceramic in matrix powder through mechanical alloying in a Szegvari attritor. The alloyed powder is then incorporated into semi-molten Al-4Mg. Initial microstructures show well-wetted unit micron particulates with a 25% improvement in incorporation. Fractography indicates a strong interface and a microvoid coalescence failure mechanism. Modifications in powder treatment and compocasting design could result in a viable composite fabrication route suitable for the automotive industry.

**COATINGS FOR HYPERSONIC FLIGHT, K. E. Wiedemann & C. R. Gautreaux,** Analytical Services and Materials, Inc., 107 Research Drive, Hampton, VA 23666. The designs for efficient hypersonic vehicles require combinations of properties not found in any single material. Specific strength at high temperatures is the most important property, but there are other critical properties, and some of these can be controlled by coatings: namely, oxidation rate, hydrogen permeation rate, radiant emittance, and the catalytic efficiency for recombinations of atomic oxygen and nitrogen. Oxidation, hydrogen permeation, emittance, and catalytic efficiency data are presented for various  $\alpha_2$  and  $\gamma$  titanium aluminide alloys and several coating materials. The method of applying a coating can be as important as the coating composition, particularly with regard to the control of oxidation and hydrogen permeation. Sol-gel coating application is a promising technique: coatings are applied as liquids and then gelled, dried, and cured. Thermogravimetric, calorimetric, and mass spectroscopic data as functions of temperature are presented for the curing of acetate-based gels. To date, the control of emittance and catalysis have been mastered, the control of oxidation is being investigated, and the control of hydrogen permeation is being planned.



## Medical Sciences

EFFECTS OF GLUCOSE AND FRUCTOSE ON MORPHINE-INDUCED LOCOMOTOR ACTIVITY IN MICE. P. Bey, D. Brase and W.L. Dewey, Dept. of Pharmacology and Toxicology, MCV/VCU, Richmond, VA 23298.

Elevated levels of blood glucose and fructose decrease the analgesic effects of morphine in the mouse tail-flick test. The administration of glucose before morphine did not affect the baseline tail-flick time in the mice [JPET 218:318, 1981]. Morphine-induced analgesia is mediated by the opioid mu receptor; the enhanced locomotor activity (running behavior) following morphine administration is also thought to be mediated by the mu receptor. Thus, the antagonism of morphine would be reflected as a decreased locomotor response. The morphine/sugar interaction was tested in a locomotor assay which used 10 and 40 mg/kg doses of s.c. morphine administered 30 min after i.p. pretreatment with saline or sugar. Male ICR mice were tested on day one (saline pretreatment) and again three days later (saline or 5 g/kg sugar pretreatment). Each group served as its own control in a 2 x 2 dose analysis. Both glucose and fructose pretreatment antagonized morphine when compared to the saline control; the locomotor response was reduced by 27% and 68%, respectively. No antagonism occurred after galactose or mannose pretreatments. Thus, glucose and fructose attenuated the morphine-induced locomotor response though it is not known whether this interaction is mediated by the mu receptor. (Supported in part by USPHS grants DA-00490 and DA-01647 and the Commonwealth of Virginia Center on Drug Abuse Research.)

PHARMACOLOGICAL SPECIFICITY OF THE DISCRIMINATIVE STIMULUS PROPERTIES OF THE N-METHYL-D-ASPARTATE ANTAGONIST NPC 12626. Daiva J. Bobelis, Joyce Willetts, & Robert L. Balster, Dept. of Pharmacology & Toxicology, Medical College of Virginia, Richmond, VA 23298. A novel drug discrimination based upon the competitive N-methyl-D-aspartate (NMDA) antagonist NPC 12626 was assessed for pharmacological specificity. Adult male Sprague-Dawley rats were trained to discriminate 20 mg/kg i.p. NPC 12626 from saline on a standard two-lever fixed ratio 32 schedule of food reinforcement. Stimulus generalization tests were then conducted with NPC 12626, the competitive NMDA antagonist 3-((+/-)-2-carboxy-piperazin-4-yl)propyl-1-phosphonic acid (CPP), the non-competitive NMDA antagonist phencyclidine (PCP), pentobarbital, diazepam and NMDA. NPC 12626 dose-dependently substituted for the training dose of NPC 12626. CPP (0.3-17.3 mg/kg i.p.) completely substituted for NPC 12626. PCP (0.3-5.6 mg/kg i.p.), pentobarbital (1.0-17.3 mg/kg i.p.), diazepam (0.3-5.0 mg/kg i.p.) and NMDA (3.0-56 mg/kg i.p.) failed to substitute for NPC 12626. These data indicate discriminative stimulus properties of NPC 12626 are selective and shared by CPP, but not PCP, pentobarbital, diazepam nor NMDA. (Supported by NIDA Grant DA-01442).

COMPARISON OF IN VITRO AND IN VIVO TREATMENT WITH OXYMETHOLONE ON IMMUNOCOMPETENT CELLS. L.A. Burns, R. Brown\*, D. Musgrove\* and A.E. Munson. Dept. Pharm. & Tox., Medical College of Va./Va. Commonwealth Univ., Richmond, VA 23298

The purpose of these studies was to determine the effects of the synthetic androgen oxymetholone (OXM) on immune function. Female B6C3F1 mice were treated with OXM for 14 days by oral gavage in doses between 8 and 200 mg/kg. Body and organ weights and selected serum chemistries were analyzed. Of the organs measured, a dose dependent decrease was noted in thymus weight which reached 73% of control values, while kidney weight increased in a dose dependent manner up to 16% above control. Serum SGPT levels, an indicator of acute liver damage, were dose dependently increased from 59 IU to 157 IU in the absence of any apparent effect on liver weight. Humoral immune response was measured by the IgM antibody forming cell (AFC) response of spleen cells to the T-dependent antigen sheep red blood cells (SRBC). There was no effect on the AFC response in doses tested. This indicates that components of the humoral immune response are still intact. The *in vitro* T-dependent AFC response to SRBC was also assessed. Spleen cells in culture treated with OXM in concentrations between  $10^{-5}$  and  $10^{-4}$  M exhibited a dose dependent decrease in AFCs/ $10^6$  splenocytes with an ID<sub>50</sub> (immunosuppressive dose) of approximately 14 µg/ml ( $6 \times 10^{-5}$  M) and a CD<sub>50</sub> (cytotoxic dose) of 22 µg/ml ( $7 \times 10^{-5}$  M). The apparent dichotomy between the *in vivo* and *in vitro* response to OXM is not known, but may be related to the pharmacokinetics of the compound. (Supported by NIEHS contract ES55094 and training grant ES07087.)

**B LYMPHOCYTE IS IMMUNE CELL TARGET FOR DIDEOXYADENOSINE.** Wei Cao\*, E.E. Sikorski\*, B.A. Fuchs\*, M. L. Stern\* and A. E. Munson. Dept of Pharmacol. and Toxicol., MCV/ VCU, Richmond, VA 23298. Dideoxyadenosine (ddA) is a drug in clinical trial for the treatment of AIDS. Tier I immunological studies showed that ddA administered to B6C3F1 female mice for 22 days over a 30 days period, dose dependently suppressed the IgM antibody forming cell (AFC) response to sheep red blood cells (sRBC), producing a 96% reduction in AFC responses at 350 mg/kg. The purpose of this study was to determine the immune cell targeted by ddA. The in vitro AFC assay was used to first determine if the target cells were adherent (A) or/and non-adherent (NA). When A cells from ddA treated mice were combined with NA cells from control mice, a normal response was obtained. When NA cells from ddA treated mice were combined with A cells from vehicle treated mice a suppressed response was obtained. This indicates that ddA affects NA cells, which include T and B lymphocytes. Using normal A cells for antigen processing, separation and reconstitution studies were carried out. These studies used purified T cells and B cells from vehicle and ddA treated mice. When T cells from ddA treated mice were combined with B cells from vehicle treated mice, a normal response was obtained. When B cells from ddA treated mice were combined with T cells from vehicle treated mice a suppressed response was obtained. This indicates that the B lymphocyte is the cell targeted by ddA. This information provides a data base for clinical use. (Supported by NIHES 55094 and training grant NIHES 07087.)

**PROCESSING PRO-TRANSFORMING GROWTH FACTOR- $\alpha$  (TGF- $\alpha$ ).** Erika Cappelluti\* and Robert B. Harris, Dept. Biochem., Va. Commonwealth Univ., Richmond, Va. 23298. TGF- $\alpha$ , a mitogenic peptide-hormone, is derived from its precursor protein by limited proteolysis. Its level of expression and secretion is elevated in transformed cells. Succ-Ala-Ala-Ala-2NA, a fluorogenic peptide substrate which contains the sequence at one of the putative processing sites, was synthesized and used to probe subcellular fractions prepared from parental and transformed rat liver epithelial cells for the presence of an enzyme with the requisite specificity to be considered a processing enzyme of proTGF- $\alpha$ . An "elastase-like" enzyme has been identified which cleaves the Ala-2NA bond exclusively. The enzyme is enriched in the nuclear and microsomal fractions and is inhibited by serine proteinase inhibitors,  $\alpha_1$ -antiproteinase and EDTA. There is a 4-fold overall increase in the level of the enzyme in the subcellular fractions prepared from the transformed cells suggesting the enzyme may be induced upon transformation.

**SIMILARITIES IN THE MODE OF BINDING OF INDOLEALKYLAMINES (IAA) AND PHENALKYLAMINES (PAA) AT 5-HT<sub>2</sub> SITES.** C.S. CHAURASIA\* R.A. GLENNON\* Dept. of Med. Chem., MCV/VCU, Richmond, VA 23298. Earlier studies from our laboratories suggested that (a) the benzene-ring portion of IAAs is important for binding at 5-HT<sub>2</sub> sites, (b) IAAs interact at 5-HT<sub>2</sub> sites in such a manner that the N1- and/or 7-position may be associated with a hydrophobic binding region, and that (c) there are similarities between IAAs and PAAs in their modes of binding at 5-HT<sub>2</sub> sites. To test the hypotheses we synthesized several  $\alpha$ -methyltryptamines ( $\alpha$ -MeT) that either lack the benzene-ring portion of the molecule, or that are substituted at the N1- or 7-position with hydrophobic substituents. These agents were examined using standard radioligand binding assays (rat frontal cortex homogenates) with [<sup>3</sup>H]ketanserin as ligand. Consistent with our hypothesis, removal of the benzene-ring portion abolished affinity for 5-HT<sub>2</sub> sites. The N1- and 7-substituted  $\alpha$ -MeT analogs all displayed a higher affinity for 5-HT<sub>2</sub> sites than  $\alpha$ -MeT itself. Agent, followed by Ki (nM) values:  $\alpha$ -MeT, >10,000; 1-Propyl- $\alpha$ -MeT, 1,550; 1-Amyl- $\alpha$ -MeT, 100; 7-Propyl- $\alpha$ -MeT, 1,040 and 7-Amyl- $\alpha$ -MeT, 140. (PHS grant # 23520).



ACUTE BONE INFECTION AND BONE SCREWS COATING WITH SILVER STEARATE MONOLAYERS. Germille Colmano, M.J. Dallman, and T. Inzana, College of Veterinary Medicine, VPI & SU, Blacksburg, VA 24061. In a preliminary study for the control of osteomyelitis, associated with open fractures, the 12 tibiae of 6 adult dogs were acutely infected with an inoculum of  $1.8 \times 10^7$  colony forming units (CFU) of Staphylococcus intermedius. Then bone screws, coated with 30 silver stearate monolayers, were randomly placed in six right or left tibiae and the silver was activated by 30 microamperes Positive Direct Current for 20 minutes. The uncoated screws, untreated by current, were placed in the contralateral tibiae and kept as controls. After 5 days the bones and the screw were cultured and a promising difference in bacterial counts, between the tibiae and the treated and untreated screws, was observed. Also SEM and x-ray analysis of the surface of the screw indicated the amount of silver present. This suggested the need for further studies, with improved techniques: using a smaller and more realistic CFU bacterial inoculum, increased amount of silver by increasing the number of monolayers, and increasing the time of current application.

BETA CAROTENE IN SERUM OF SMOKELESS TOBACCO USERS. B. P. Dezzutti, W. Chan, G. Kaugers\* & R.B. Brandt. Dept of Biochemistry & Dept of Oral Path., Med. Col. Va., Va. Commonwealth Univ., Richmond, Va. 23298. About 10 million Americans are smokeless tobacco users (STU). Half of all STU may have epithelial changes.  $\beta$ -Carotene(BC) reduces the risk of developing some cancers. STU were selected to study the effect of BC in preventing the development of oral lesions. Subjects were from the Outpatient Clinic of the Oral Surgery Dept. Each received an oral examination, and donated 10ml of blood. Controls had never used ST. Serum was analyzed for total carotenoids using a modified Mathews-Roth method and HPLC. The HPLC methodology allowed the simultaneous determination of specific carotenoids and retinoids. Forty white males participated in the study. Of these 11 were STU with oral lesions, 15 were STU with no oral lesions and 14 were controls. Analysis of the total serum carotenoids (ug/dL) with (mean,SEM):STU with lesions (132,13); STU with no lesions (205,23); Controls (192,14). There is significant ( $P < 0.01$ ) difference for the STU with lesions and the other groups. BC analysis gave similar differences. The results support a possible relationship between the low levels of BC and the development of oral lesions in STU. Retinoid analysis did not show correlation between groups. Supported by the Smokeless Tobacco Foundation.

RESOLUTION OF MACROPHAGE FACTORS WITH AMOEBOICIDAL AND TUMORICIDAL ACTIVITY. K. Fischer-Stenger, G. Cabral\* and F. Marciano-Cabral, Dept. of Micro./Immunol., Va. Commonwealth Univ., Richmond, Va. 23298-0678. Conditioned medium (CM) from lipopolysaccharide-stimulated cultures of mouse peritoneal macrophages (M $\phi$ ) activated *in vivo* by bacillus Calmette-Guérin (BCG) or Corynebacterium parvum demonstrated cytolytic activity for Naegleria fowleri amoebae and L929 tumor cells. Cytolytic activity was measured by release of radiolabel from  $^{111}$ Indium-oxine-labeled amoebae or tumor cells after a 20 hour incubation with M $\phi$  CM. Anti-TNF rabbit serum inhibited tumoricidal activity present in BCG and C. parvum CM and reduced amoebicidal activity in BCG CM but not in C. parvum CM. Recombinant MuTNF $_{\alpha}$  but not rMuIL-1 $_{\alpha}$  lysed L929 tumor cells. Neither rMuTNF $_{\alpha}$  nor rMuIL-1 $_{\alpha}$  alone was cytolytic for N. fowleri amoebae. Activated M $\phi$  CM fractions exhibiting amoebicidal and tumoricidal activity were separated by preparative flat-bed electrofocusing. The activity profiles differed for N. fowleri amoebae and L929 tumor cells. Analysis by SDS-PAGE of fractions obtained from the preparative electrofocusing procedure revealed different proteins in fractions exhibiting amoebicidal or tumoricidal activity. These results indicate that different M $\phi$  factors are responsible for amoebicidal and tumoricidal activity.



PROLACTIN-GLUCOCORTICOID INTERACTIONS IN NB2 LYMPHOMA CELLS. S. Fletcher\*, M.Y. Kalimi\*, R.J. Witorsch\*. Dept. Physiology, MCV/Va. Commonwealth Univ., 23298. The pre-T, Nb2 rat lymphoma cell line is known to be very sensitive to the mitogenic action of prolactin (PRL). The purpose of this work was to study the action of glucocorticoids (GCs) on this cell line *in vitro*. Addition of dexamethasone (Dex) caused a dose-(3-200nM) dependent inhibition of ovine PRL-(NIADDK,o-15) induced proliferation of Nb2 cells (<80%). Very high doses of PRL (160pM) were incapable of reversing this effect of Dex. This action of Dex was reversed by the GC antagonist RU 486 and was mimicked by 1  $\mu$ M of corticosteroids (corticosterone, cortisol, aldosterone) but not by androgens, estradiol, or progesterone. In the absence of PRL, Dex caused a dose-(12.5-400 nM) and time-(12-48 hr) dependent increase in cell death (>90%). This effect was reversed by RU 486 and mimicked by other corticosteroids while androgens, estradiol, or progesterone showed little or no cytolytic activity. Prolactin was capable of reversing the cytolytic action of Dex in a dose-dependent (1-70 pM) fashion. We conclude that: 1) GCs exert antiproliferative and cytolytic effects on Nb2 cells; and 2) only the cytolytic effect of GCs is reversed by PRL. (Supported by grants from the Jeffress Trust and the MCV Fdn)

THE PROTEIN CONTENT OF HUMAN LENS TISSUE. Claire E. Fornsel and H. Alan Rowe, Department of Chemistry Norfolk State University, Norfolk, Virginia 23504

Frequently complex diseases manifest themselves by biochemical alterations in peripheral tissues. This study investigates the correlation between protein concentration in lens tissue and cardiovascular disease, the leading cause of death in this country. Donor eyes were classified according to the cause of death as either cardiovascular related deaths or other causes of death. Lenses, which are located directly behind the pupil were removed from the donor eye, minced and weighed. The lenses were then solubilized in a 2X deionized water-pen/strep mixture at four degrees Celsius and centrifuged. A 1:100 serial dilution was made and the samples were assayed for proteins using the Lowry Method. The average age of cardiovascular donors and non-cardiovascular donors was found to be fifty three-years and sixty-one years respectively. The protein concentration in the cardiovascular related and non-cardiovascular group was found to be 118 +/-15.2 and 118 +/- 18.3 milligrams of protein per gram of lens. There was a large variation in protein concentration between lenses from the same donor. Supported by NIH-MARC and LIONS Medical Eye Bank and Research Center.

ELECTRONIC PROPERTIES OF DYSTROPHIC MUSCLE MEMBRANE SYSTEMS.

Gwendolyn L. Geffert \* and M.J. Allen, Biophysical Laboratory, Dept. of Chemistry, Va. Commonwealth Univ., Richmond, VA 23284 The genetic differences between 'normal' and dystrophic musculature have been well documented in recent years. In order to further elucidate these diverse characteristics, the electronic properties of muscle tissue of dystrophic mice and their phenotypically normal litter mates were examined. Utilizing various electrical techniques it was found that the electron:hole (electron receptor sites) ratio, Arrhenius plots of conductance vs 1/T and the activation energies obtained therefrom, and the effects of pressure on the muscle membranes demonstrated significant differences.

THE BEHAVIORAL EFFECTS OF  $\Delta^9$ -THC IN DIFFERENT MOUSE STRAINS. M.R. Green,\* E.S. Onaivi,\* R.L. Winckler,\* and Billy R. Martin, Dept. Pharm./Toxicology, MCV - VCU, VA 23298.

$\Delta^9$ -Tetrahydrocannabinol (THC) produces a myriad of effects in both laboratory animals and man. Several behavioral effects of  $\Delta^9$ -THC were studied in C57/BL6, DBA/2, and ICR mouse strains following intraperitoneal (ip) administration. The administration of  $\Delta^9$ -THC (50 mg/kg) produced a similar reduction in spontaneous locomotor activity (by 84%, 87% and 70%), reduction in rectal temperature (by 2.0°C, 4.2°C, 3.5°C), and an increase in tail-flick latency as measured by %MPE (from 16% [veh] to 80%, 36% [veh] to 64%, 28% [veh] to 94%) in C57/BL6, DBA/2, ICR mouse strains. The average immobility rating produced by vehicle (21%) in all three species was increased by  $\Delta^9$ -THC (to 56%, 49%, and 53%) in C57/BL6, DBA/2, and ICR mouse strains, respectively.  $\Delta^9$ -THC (10 and 20 mg/kg) induced mouse aversion to the open arms of the elevated plus-maze test in ICR (37% and 70%) mice but not in DBA and C57/BL6 mice. It is concluded that some behavioral changes following  $\Delta^9$ -THC administration may be attributed to strain differences. Supported by NIDA grant #DA 03672 and Commonwealth of Virginia Center on Drug Abuse.

THE EFFECTS OF PROTEIN KINASE INHIBITORS ON THE RESPONSES OF THE VITAMIN D<sub>3</sub> DIFFERENTIATED HL-60 CELL. K.R. IORIO AND R. A. CARCHMAN,\* DEPT OF PHARMACOLOGY & TOXICOLOGY, MEDICAL COLLEGE OF VA, VCU. RICHMOND, VA 23298.

The human promyelocytic leukemia cell line (HL-60) when incubated in the active form of Vitamin D<sub>3</sub> (D<sub>3</sub>) has been shown to exhibit many characteristics of the human monocyte. Since mononuclear phagocytes play an important role in host defense, it is of considerable interest to investigate the subcellular signaling events involved in some of these responses. Superoxide anion (SOA) production was measured when D<sub>3</sub> cells were exposed to several agents (PMA, OpZ, Ionomycin, & fMLP). Both PMA and OpZ caused concentration-dependent generation of SOA, while there was no SOA production to fMLP and Ionomycin. There was no correlation with effects of these agents on calcium. A strong response to PMA, which is a potent activator of protein kinase C, suggested the possible involvement of one or more protein kinases. In order to differentiate between several protein kinases we chose to use three distinct protein kinase inhibitors, trifluoroperazine, W-7, and H-7, and measure their effects on SOA generation elicited by PMA and OpZ.

VARIOUS ASPECTS OF NICOTINE TOLERANCE. J.R. James, H.F. Villanueva, & J.A. Rosecrans, Dept. of Pharmacology, VA. Commonwealth Univ., Richmond, VA. 23298. The present investigation evaluated the development of tolerance in animals to the response disrupting effects of nicotine. The purpose of this evaluation was to further identify the mechanisms of this tolerance. Initially, pre- and post-session designs were utilized in rats responding for food reinforcement during a schedule-controlled operant session. Dose-response curves determined before and after chronic nicotine treatment were similar for the two treatment groups (pre and post), suggesting that pharmacological mechanisms were responsible for the development of tolerance to nicotine. Continuing investigations into the development of tolerance to nicotine in mice have produced single dose tolerance to nicotine which was evident 14 days following the initial dose of nicotine. This suggests not only that tolerance to nicotine is mediated by pharmacological mechanisms, but that this tolerance develops rapidly and is of longer duration than previously believed. Work in progress suggests that the tolerance is not only mediated by pharmacological mechanisms, but that there is a robust behavioral component.



USE OF INTRACEREBRAL MICRODIALYSIS PROBES: SOME METHODOLOGICAL CONSIDERATIONS. James H. Johnson, Dept. of Anatomy, Virginia Commonwealth Univ., Richmond, VA 23298. This study was done to validate the use of a brief ether anesthesia during insertion of the microdialysis probes in chronically implanted guide tubes on the day of the experiment with a 60-minute latency to onset of collection of dialysis samples from unanesthetized animals. Carnegie Medicin microdialysis probes were inserted into guide cannulae, and perfused at a rate of 5  $\mu$ l/minute with a 0.85% NaCl solution containing 4 mMolar KCl and 2.3 mMolar  $\text{CaCl}_2$ . Immediately following this 10-20 minute ether anesthesia, 6 10-minute (50  $\mu$ l) fractions of dialysate were collected and assayed using HPLC with electrochemical detection for catecholamines and indoleamines. The results were expressed as nMolar concentrations of each analyte. Results were analyzed statistically using ANOVA followed by a contrast procedure. Significant ( $p < 0.05$ ) variations were identified in hypothalamic recoveries of norepinephrine, dopamine and 5HIAA, and in preoptic norepinephrine and 5HIAA between samples 1-3 and 4-6. With the exception of hypothalamic 5HIAA these differences were not seen in contrasts of samples 4 vs 5-6. These results indicate that most substances reach baseline stability within the 60-minute latency period.

INDUCTIVE MECHANISMS OF HEME OXYGENASE, A STRESS-INDUCED PROTEIN. C.L. Jones and K.R. Shelton, Dept. of Biochem. & Mol. Biophys. MCV/VCU, Richmond, VA.

Challenge of rat skin fibroblasts with heavy metals (Cd, Pb), 1-chloro-2,4-dinitrobenzene (CDNB), arsenite, arsenate, t-butyl hydroperoxide or  $\text{Cu}^{2+}$  ionophores (dithizone, o-phenanthroline) strongly induces the synthesis of a 30-kDa stress protein which has been identified as heme oxygenase (HO). Decreasing intracellular GSH levels with L-buthionine sulfoximine (BSO) does not induce HO synthesis. CDNB induction of HO is enhanced by prior depletion of GSH levels with BSO. Induction by arsenate and arsenite is also further enhanced by prior treatment of the cells with BSO indicating that arsenate functions via a thiol-related mechanism. t-butyl hydroperoxide induces HO synthesis at high levels of inducer and is enhanced by concomitant inhibition of GSH reductase. The addition of  $\text{Cu}^{2+}$  along with o-phenanthroline or dithizone leads to significantly enhanced expression of HO. A sensitive cellular SH group, normally shielded in the cell by high levels of GSH, is proposed as a target in the mechanism of SH30 induction.

PHARMACOLOGICAL ACTIVITY OF NOVEL BICYCLIC ANALOGS OF  $\Delta^9$ -TETRAHYDROCANNABINOL ( $\Delta^9$ -THC) OBTAINED USING A MULTIPLE EVALUATION PARADIGM. Kevin D. Jordan,\* David R. Compton, Ramona L. Winckler,\* and Billy R. Martin, Dept. Pharm./Tox., MCV-VCU, Rich., VA 23298. A variety of novel bicyclic analogs of  $\Delta^9$ -THC have been shown to possess antinociceptive properties (Johnson and Melvin, 1986). However, the efficacy of most of these analogs in producing other types of cannabimimetic activity is unknown. Therefore, ten bicyclic analogs were evaluated in a multiple behavioral paradigm where each mouse was evaluated in four different behaviors sequentially, rather than each behavior individually, since results obtained between both methods were identical for 6 mg/kg  $\Delta^9$ -THC. All analogs (like  $\Delta^9$ -THC) decreased motor activity and temperature, as well as produced antinociception and catalepsy following intravenous administration. However, four analogs (unlike  $\Delta^9$ -THC) failed to elicit the maximum (100%) antinociceptive response. Therefore, two analogs were evaluated following s.c. administration and a maximum antinociceptive response was observed. Interestingly, there was no change in the effect observed in the other behaviors compared to i.v. drug. Thus, the pharmacological activity of these bicyclic analogs is similar to that of  $\Delta^9$ -THC, though antinociception appears to be influenced by route of administration. (Supported by NIDA Grant DA-03672 and Commonwealth of Virginia Center on Drug Abuse.)



**Hypermagnesia fails to produce phencyclidine-like discriminative stimulus effects in rats.** Saeed A. Jortani, Joyce Willetts, and Robert L. Balster. Department of Pharmacology and Toxicology, Medical College of Virginia, Richmond, VA 23298. Phencyclidine (PCP) and Magnesium ( $Mg^{2+}$ ) are known to block the ion channel associated with the N-methyl-D-aspartate (NMDA) receptor complex. Thus, it is possible that increased brain concentrations of  $Mg^{2+}$  might be able to produce some PCP-like pharmacological effects. The PCP-like discriminative stimulus effects of  $Mg^{2+}$  were investigated. Rats (n=6) were trained to discriminate PCP (1.25 mg/kg, i.p.) from saline (1.0 ml/kg, i.p.) under a two-lever fixed-ratio 32 schedule of food reinforcement.  $MgCl_2$  (10-80 mg/kg, i.p.) failed to generalize from PCP producing less than 21% PCP-lever responding. Response rates decreased following doses of  $MgCl_2$  greater than 40 mg/kg. The results indicate that hypermagnesia may not result in PCP-like behavioral effects. (Supported by NIDA Grant DA-01442)

**BONE MARROW AND THYMUS RECONSTITUTION OF LYMPH NODE GERMINAL CENTER REACTION IN AGED MICE.** Zohar F. Kapasi\*, John G. Tew and Andras K. Szakal\*. Depts. of Anatomy/Microbiology, Med. Col. of VA, VCU, Richmond, VA. 23298. Aging decreases the capacity of individuals to maintain long term humoral immunity and there is deficient formation in size and number of peanut agglutinin (PNA) positive germinal centers in aged mice. The objective of our study was to assess the effectiveness of bone marrow (BM) and thymus (Thy) transplants to reconstitute the germinal center (GC) reaction in the old mouse secondary immune response. C57BL/6 young (6-8wk) and old (24mo) mice were irradiated with 850 rads and given young BM + Thy transplants. Our results showed an increase in the mean number of PNA positive GCs (1.22 to 4.5,  $p=0.01$ ) per popliteal lymph node (PLN) in old BM + Thy transplanted mice. An increase in the mean sum of the volume of PNA positive GCs per PLN (1.9 to 10.7  $\mu m^3$ ,  $p=0.03$ ), representing PNA+ GC compartment size, was also detectable. However, no significant increase occurred in mean GC size. This suggests that the increase in compartment size in old BM + Thy transplanted mice is due to an increase in the number of GCS per PLN. Thy +BM transplants in this study appeared to reconstitute the GC reaction resulting in the approximation of mean GC numbers in young PLN (i.e. 4.5/old vs. 6.1/young). (Supported by NIH Grant AG-05374 and A.D. Williams Research Grant).

**LOCALIZATION OF THYMOSIN ALPHA-ONE IN MCF-7 HUMAN BREAST CANCER CELLS.** Karen K. Oates, William J. Karppi Jr., Dept. of Biol, George Mason Univ., Fairfax, Va 22030. The estrogen dependent human breast cancer cell line MCF-7 has been used to study autocrine synthesis of the polypeptide hormone thymosin alpha-one (TA1). TA1 is a 28 amino acid polypeptide that has been shown to increase viral, fungal and tumor immunity in aging mice. It has also been shown to enhance T-cell immunity in humans. Preparative HPLC followed by radioimmunoassay showed that these cells produce significant levels of TA1 when grown in thymosin-free media. Anchorage dependent and soft agar growth of MCF-7 cells was stimulated by the addition of TA1 at a final concentration of  $10^9$  mg per ml to the growth media. We have used indirect immunofluorescent antibody staining to localize TA1 in the cytoplasm of whole fixed cells. No fluorescence was observed in the nuclei of these cells. N- and C-terminal  $^{125}I$ -labeled TA1 were used to measure the binding characteristics of this hormone. To date, time, temperature and competition assays have been conducted. SEM and TEM studies of MCF-7 cells labeled with anti-TA1 antibody and visualized with gold-antibody conjugates showed numerous sites believed to contain TA1 within the cytoplasm of these cells.

**CHARACTERIZATION OF A DEVELOPMENTALLY-REGULATED LOW ABUNDANCE NUCLEAR MATRIX PROTEIN.** Eric Klann\* and Keith R. Shelton, Dept. of Biochemistry and Molecular Biophysics, MCV-VCU, Richmond, VA 23298. The developmentally-regulated nuclear matrix protein p32/6.3, a trace component in all nuclei, is enriched in the nuclei of cerebral cortex neurons and the mouse neuroblastoma 2a cell line. p32/6.3 levels increase rapidly postnatally, reaching adult levels 10 to 20 days after birth in rat and guinea pig cerebral cortex and chicken forebrain. Induction of neuroblastoma differentiation into neuron-like cells increases p32/6.3 levels 2- to 3-fold. These increases correlate with the extension of neurites and dendrites in both systems, suggesting a role for p32/6.3 in neuronal differentiation. The protein has been purified and cleaved both proteolytically and chemically to obtain peptide fragments for sequencing from PVDF membranes. Preliminary sequence analysis of these fragments indicate that p32/6.3 is a unique nuclear matrix protein.

**LACTOGEN-INDUCED PROTEIN PHOSPHORYLATION IN NB2 LYMPHOMA CELLS.** L.J. Kornberg\* and J.P. Liberti, Dept. of Biochem., Med. Coll. of VA/VA Comm. Univ., Richmond, VA 23298.

Nb2 cells are exquisitely sensitive to lactogenic hormones. Although such cells are an ideal system to study receptor-mediated signal transduction which occurs prior to mitogenesis, relatively little is known about these early events. Because selective phosphorylation/dephosphorylation of specific proteins by many polypeptide hormones may be important in regulating cell growth, the effect of lactogenic hormones on protein phosphorylation was studied. Growth-arrested NB2 cells, maintained in serum-free medium, were incubated various times with lactogenic hormones and pulsed for 0.5 h with  $^32P$ , prior to terminating the reaction. Phosphoproteins in the cell extracts were fractionated by SDS-PAGE. Results showed that 200pM hGH promoted phosphorylation of many proteins (3-fold) and an  $M_r = 29,000$  species (pp29) ( $\geq 10$  fold). In extended incubations (up to 12h) phosphorylation of pp29 peaked 4h after addition of hGH. Ovine PRL, another mitogenic hormone, caused a concentration-dependent increase in pp29 phosphorylation ( $EC_{50} = 10-20$  pM). Rat GH, which is non-mitogenic in Nb-2 cells, did not induce pp29 phosphorylation. Other non-mitogenic agents such as phorbol ester (100 nM; TPA), 8-Br-cAMP (1mM), and 8-Br-cGMP (1mM) did not affect pp29 phosphorylation. Dexamethasone (100nM), which inhibits lactogen-stimulated growth, reduced hGH-stimulated pp29 phosphorylation to control levels. **Summary:** These results indicate that 1) lactogenic hormones induce the phosphorylation of a protein (pp29) in a time and concentration dependent manner; 2) protein phosphorylation is closely associated with cell growth; 3) activation of protein kinase A, protein kinase C and cAMP-dependent kinase, does not induce pp29 phosphorylation. **Conclusion:** Phosphorylation of pp29 correlates well with cell growth and may be an important intracellular signal for lactogen-induced mitogenesis.

**COMPARISON OF DIFFERENT FORMS OF A METALLO-ENDOPEPTIDASE FROM MOUSE KIDNEY BRUSH BORDER MEMBRANES.** Maria Z. Kounnas\* and J. S. Bond, Dept. of Biochem., Virginia Tech, Blacksburg, VA 24061. Meprin, a kidney brush border membrane-bound metallo-endorpeptidase, is present in mice in two forms. A high activity form, designated meprin-a, is present in many inbred and random-bred strains of mice including ICR; a low activity form, meprin-b, exists in other inbred strains of mice, such as C3H. The relationship between and differences among these forms of meprin is not understood. A purification scheme was devised involving the release of forms of meprin from kidney membranes by papain. Purified forms are designated meprin-a<sup>pap</sup>, which is a single major protein with a subunit size of 85 kDa, and meprin-b<sup>pap</sup>, which consists of three major polypeptides with subunits of 85, 140, and 160 kDa. Following purification, protein bands were electroeluted from an SDS-gel and treated with an endo-proteinase, Glu-C. Peptide fragments resulting from this treatment were separated on a 20% SDS polyacrylamide gel and stained with Coomassie blue. These techniques will help to determine both the similarities and differences in the primary sequence of the different forms of meprin and help to explore regulatory regions on proteases. (Supported by NIH grant DK 19691).



MODULATION OF HUMAN MONOCYTE FUNCTION BY PROTEIN KINASE INHIBITORS, H7 and W7. Caroline M. Kramer, Richard A. Carchman,\* and Barbara A. Kelly.\* Dept. of Pharmacology and Toxicology, MCV-VCU, Richmond, VA 23298. Human monocytes can be stimulated by phorbol myristate acetate (PMA), opsonized zymosan (OPZ) or the calcium ionophore ionomycin to release lysosomal enzymes (LER) or to produce superoxide anion (SOA). Our present studies have focused on the role of Protein Kinase C (PKC), calcium-dependent, phospholipid-stimulated protein kinase, in these responses. The PKC inhibitor H7, which acts at the catalytic site of PKC, inhibited both LER and SOA by PMA, but was more effective at inhibiting SOA than LER by ionomycin and OPZ. These results support a role of PKC in SOA production and in both SOA and LER by PMA. W7, an inhibitor of the phospholipid interacting site of PKC, inhibited SOA by all three stimuli, further supporting a role of PKC in the SOA response. However, W7 alone caused a large increase in LER. This response to W7 did not involve any effect on intracellular calcium concentrations. The mechanism for this effect of W7 is unknown at present. In summary, these results support a role of PKC in SOA production by various stimuli of the human monocyte, and in LER by the phorbol ester, PMA. (Supported by a grant from the MCV-VCU Cancer Center to CMK.)

Morphometric analysis of the effects of beta-estradiol on accessory sex glands of male Swiss-Webster mice. R. David Lee and Roman J. Miller, Dept. of Biology, Eastern Mennonite Col., Harrisonburg, VA 22801. Eight treatment groups of intact adult mice were formed and received three injections per week for a four week period: Oil (control); EA (0.01 mg estradiol/kg body weight); EB (0.1 mg/kg); EC (1 mg/kg); ED (10 mg/kg); T (10 mg testosterone/kg body weight); EB+T; EC+T. After treatment, seminal vesicles and anterior prostates were removed, fixed in Bouin's solution, embedded in paraffin, sectioned at 6  $\mu$ m, and stained with hematoxylin and eosin. Morphometric analyses were based on lumen, glandular, and stromal tissue components. Increasing estrogen dosages produced a stepwise decline in the amount of lumen ( $\mu$ l component/ $\mu$ g organ) to 50% and 30% of the control in anterior prostate and seminal vesicle, respectively. No significant changes from control were noted in the glandular components. Testosterone treatment resulted in decreased stroma amount ( $\mu$ g component/ $\mu$ g organ) to 60% of control values for seminal vesicle. The influence of estrogen in combination with testosterone negated this testosterone effect in EB+T and EC+T groups. Stroma content for anterior prostate and seminal vesicle increased 260% and 280% respectively from control values in direct proportion to the concentration of estrogen administered.

STIMULUS EFFECTS OF DESIGNER DRUGS IN RATS TRAINED TO DISCRIMINATE MDMA ("Ecstasy") FROM SALINE. B. Misenheimer\* R.A. Glennon\* Department of Medicinal Chemistry, MCV/VCU Richmond, VA 23298. MDE ("Eve") and N-OH MDA, two clandestinely produced drugs of abuse, are structurally related to the "designer drug" MDMA ("Ecstasy", "Adam"). Both are being considered for control as Schedule I substances. We have previously demonstrated that, unlike MDMA, neither MDE nor N-OH MDA produce stimulus effects similar to those of amphetamine. In this present study, we investigated the possibility that these agents might produce MDMA-like effects in MDMA-trained rats. Male Sprague-Dawley rats were trained to discriminate 1.5 mg/kg (ip; n=6) of MDMA from saline in a standard 2-lever operant procedure under a VI 15-sec schedule of reinforcement. Both agents produced MDMA-like responding; ED50 values are MDMA: 0.8 mg/kg, MDE: 0.7 mg/kg, and N-OH MDA: 0.5 mg/kg. The present results show that both agents are capable of mimicking the stimulus effects of MDMA. Furthermore, they suggest that MDMA, MDE, and N-OH MDA are not simple amphetamine-like agents. Consistent with this idea, the MDMA-stimulus did not generalize to (+)amphetamine. It appears that MDMA can produce effects that are other than amphetamine-like and that MDE and N-OH MDA are MDMA-like agents with even less of an amphetamine-like component of action. (Supported in part by grant DA01642 and by the Drug Enforcement Administration)



COMPUTER-ASSISTED DATA ACQUISITION AND ANALYSIS IN RAT DISCRIMINATIVE STIMULUS PARADIGMS. Jeffrey W. Mitchell\*, M. Zhu\*, W.R. Prescott, and B.R. Martin, Dept. of Pharm/Tox, MCV-VCU, Richmond, VA 23298. We describe a system utilizing a *Commodore 64*™ computer and the powerful, easy to use algorithms in the *Promal*™ language. This system is capable of controlling up to 8 operant chambers, each with two response levers, house lights and a pellet feeder. Extensively tested routines for both fixed-ratio and variable-interval schedules of reinforcement are currently being used in this system in which the computer/chamber interface is 28-V optoisolated, solid state circuitry. Some additional advantages include: higher level program language which eliminates the need for cumbersome machine language code, on-screen real-time monitoring, and independent control of the individual chambers. We have also programmed for automated, electronic data transfer between the *Commodore 64*™ and a *Macintosh*™ in a format suitable for direct incorporation into the myriad of *Macintosh*™ spread-sheet, data base and graphing packages. The daily sessions generate a total of 1200 numbers for our colony of 60 animals which must be constantly reviewed. Consequently, the prohibitive amount of data could not effectively and efficiently be utilized without the benefits of this system. Automated data handling in behavioral labs: allows for a more complete data base and a more varied analysis, eliminates transcription errors, and makes feasible the study of a larger numbers of animals. Hence, experimental results have greater statistical power (Supported by the Virginia Commonwealth Center for Drug Abuse and NIDA DA 03672).

THE EFFECT OF MORPHINE TOLERANCE ON THE MODULATION OF FREE INTRACELLULAR CALCIUM BY MU, DELTA, AND KAPPA OPIATE RECEPTOR-SPECIFIC LIGANDS. Kirsten G. Olson, S. P. Welch, D. L. Stevens, and W. L. Dewey, Dept. of Pharmacology and Toxicology, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23298. Previous work by our lab has shown that morphine-tolerant mice had significantly higher basal free intracellular calcium  $[Ca^{++}]_i$  levels compared to placebo and naive mice. The effect of opiate receptor-specific ligands on basal levels of  $[Ca^{++}]_i$  is more pronounced in morphine-tolerant than in naive mice. The opiate receptor-specific effects on  $[Ca^{++}]_i$  were evaluated using the following ligands in morphine-tolerant and naive mouse whole-brain synaptosomes: morphine and DAMGO ( $\mu$ ), DPDPE ( $\delta$ ), and U50,488H ( $\kappa$ ). DAMGO ( $10^{-5}$  to  $10^{-8}$ M) and morphine ( $10^{-6}$  to  $10^{-8}$ M) produced a dose-related naloxone reversible attenuation of depolarization-induced increase in  $[Ca^{++}]_i$  in naive but not morphine-tolerant mice. DPDPE ( $10^{-5}$  and  $10^{-6}$ M) did not alter basal or stimulated levels of  $[Ca^{++}]_i$  in naive or morphine-tolerant mice. U50,488H produced a significant nor-BNI reversible attenuation of depolarization-induced increases in  $[Ca^{++}]_i$  at  $10^{-5}$ M in naive mice but not in morphine-tolerant mice. These data indicate that the production of tolerance in mice may result from a neuronal up-regulation of intracellular  $Ca^{++}$  levels. Tolerance to morphine results in cross-tolerance to  $\mu$ , but not  $\kappa$  ligands;  $\delta$  ligands appear inactive in this system. (Supported by NIDA grants DA01647-12 and F32-DA05340-02).

RATIONAL APPROACHES TO THE DESIGN OF SELECTIVE 5-HT<sub>1A</sub> LIGANDS. Revathi Raghupathi\*, N.A. Naiman\*, R.A. Glennon\*, Dept. of Medicinal Chemistry, MCV/VCU, Richmond, Va 23298. 4-(2-Methoxyphenyl)-1-[4-(2-phthalimido)butyl]piperazine (NAN-190), an agent recently developed in our laboratory, has a high affinity for 5-HT<sub>1A</sub> serotonin receptors ( $K_i = 0.6$  nM) and may constitute the first useful example of a 5-HT<sub>1A</sub> antagonist. Unfortunately, this agent also binds at  $\alpha_1$ -adrenergic sites ( $K_i = 0.8$  nM). A series of compounds was made, retaining the 4-(2-methoxyphenyl)-1-(n-butyl)piperazine portion, which was found to be important for 5-HT<sub>1A</sub> activity, and varying the phthalimido moiety. The substituents had different combinations of lipophilic/non-lipophilic and electron withdrawing/donating characteristics. Structure activity relationship (SAR) studies of 5-HT<sub>1A</sub> and  $\alpha_1$  ligands indicate that some of these substituents should confer an increased selectivity for 5-HT<sub>1A</sub> sites over  $\alpha_1$  sites compared to the parent phthalimido compound. In addition, the diversity of the substituents should lead to SAR data for 5-HT<sub>1A</sub> ligands. (Supported in part by PHS Grant NS 23523.)

TESTING OF ARACHIDONIC ACID 5-LIPOXYGENASE INHIBITORS IN THE ARACHIDONIC ACID-INDUCED MOUSE EAR EDEMA MODEL. Matthew C. Sackett, L. T. Alty, D. A. Brown, C. D. Eckman, and J. F. Rowe, Dept. of Chemistry, Washington & Lee Univ., Lexington, VA 24450. Leukotrienes (LTs) and another class of chemicals, prostaglandins (PGs), are both synthesized from the precursor arachidonic acid (AA) by the enzymes 5-lipoxygenase (5-LO) and cyclooxygenase, respectively. PGs and LTs are both considered mediators of inflammation since their presence initiates a chain of biological events which causes inflammation. The AA-induced inflammation of the mouse ear is a model which has been used by several groups to test the biological activity of anti-inflammatory agents. It has been shown that the inflammation produced is due to the production of LTs, not PGs; therefore the assay is specific for measuring inhibition of the production of LTs. Maximal swelling occurs at one hour after application of 2 mg of AA to the ear. The ED<sub>50</sub> (effective dose for 50% of maximal effect) for AA in this assay was 1 mg/ear. Dose-response curves for diethylcarbamazine, a known 5-LO inhibitor, and for 5-aminosalicylic acid (5-ASA), a known anti-inflammatory drug, will also be presented. (Supported by the R. E. Lee Grant Fund, Washington & Lee Univ.)

FACTORS AFFECTING BREAST-FEEDING AND WEANING PROCESS OF BOYS AND GIRLS IN PANAMA. Irma Silva-Barbeau, Office of International Development, VPI&SU, Blacksburg, VA 24061, D. Sanjur, Div. Nut. Sci., Cornell University, Ithaca, NY, 14853. This investigation was undertaken to study the determinants of breast-feeding and weaning process for boys and girls in two semi-rural communities, in Panama. Information obtained by a standardized questionnaire, from a random sample of 190 women, indicated that 54% of mothers breast fed their children because of the nutritional and health benefits. There were no statistically significant differences between boys and girls in the length of breast-feeding, however, after 18 months more mothers continued to breast feed girls. The weaning process began for 20% at two to four months of age, however, 2% had not begun to systematically wean the girls after one year. Multivariate regression analyses indicated that the husbands' educational level was negatively correlated with the age of weaning boys ( $P=0.001$ ). Conversely per capita food expenditure and maternal economic history were more negatively correlated with age of weaning females. It was concluded that under favorable economic situation both sexes are weaned earlier, however, under more stressful conditions there may be a delay in the systematic weaning of children especially that of girls beyond what is considered desirable (i.e., five to six months).

THE EFFECTS ON BLOOD GLUCOSE LEVELS OF INTRATHECALLY ADMINISTERED DRUGS.

A.K. Singha, D.A. Brase, W.L. Dewey. Dept. of Pharmacology and Toxicology, Medical College of Virginia/VA Commonwealth University, Richmond, VA 23298

The purpose of this study was to investigate the mechanism of the hypoglycemic effect of morphine administered intrathecally (i.t.) in mice. Morphine (40  $\mu$ g i.t.) produced a maximum decrease in blood glucose of 75% (S.E.=5%) at 1 hr. On the other hand, blood glucose increased in mice given saline i.t. Experiments with a number of opioid drugs to characterize the type of opioid receptor involved in the morphine-induced hypoglycemia indicated that only the opioid drugs similar in chemical structure to that of morphine were able to reduce blood glucose levels. From these experiments, it appeared that a previously uncharacterized opioid receptor might be involved in the mechanism of the hypoglycemic effect. A second aspect of this study involved determining whether morphine-induced hypoglycemia was mediated by the same membrane glucose transporter that mediates the action of insulin. Two inhibitors of this transporter, forskolin and cytochalasin B (10 mg/kg) blocked the hypoglycemic effect of i.t. morphine, but potentiated its lethality. (Supported by grants DA-00490 and DA-01647 and the Virginia Center on Drug Abuse Research).



SMITH, J.P.\*, M.H. KOSCO\*, J.G. TEW and A.K. SZAKAL\*, Departments of Anatomy/Immunobiology and Microbiology/Immunology, Medical College of Virginia/VCU, Richmond, Virginia. TINGIBLE BODY MACROPHAGES (TBMs) AS DOWNREGULATORS OF B CELL ANTIGEN PRESENTATION IN VITRO. Tinging body macrophages are found in germinal centers (GCs) of lymphoid tissues and represent a phenotypically unique subpopulation of macrophages due to their expression of Thy-1.2 antigens. Functionally, their expression of Ia Ags and ability to endocytose Ag suggests that TBM may be capable of Ag presentation in the GC response. In the present study, Ag presentation ability by TBMs was assessed using a similar assay system which showed Ag presentation by GC B cells to the ovalbumin specific IL-2 producing T<sub>H</sub> hybridoma 3D0-54.8. The results show that TBM are not good Ag presenting cells. In contrast, the addition of TBM to GC B cells + 3D0s resulted in a 10 fold decrease in IL-2 production by 3D0s. Preliminary histochemistry suggests that TBM produce prostaglandins which could account for this downregulatory effect. (Supported by NIH grant AI 17142.)

SELECTED BIOLOGICAL AND BEHAVIORAL VARIABLES AFFECTING SMOKING BEHAVIOR. Martha N. Smith, Dept. of Prev. Med., Richard Brandt & Brian Dezzutti, Dept. of Biochemistry, Va. Commonwealth Univ., Richmond, VA., 23298. 127 adult employees representing several SES levels at a mid-Atlantic university were examined for more than 200 selected biological and behavioral variables thought to affect smoking behavior. Subjects were assigned to 1 of 3 groups according to their self-reported smoking behavior. 46 smokers reported a 1 to 37-year smoking history and were assigned to Group I; Group II, 31 subjects, had stopped smoking for at least 6 months; and Group III, 50 people, had never smoked.

The Meyers-Briggs Type Indicator was used and data suggests that smoking behavior differs according to personality. Introverts are less likely to indulge in smoking behavior and more likely to successfully quit. Cardiopulmonary examination and spirometry revealed pulmonary changes and decreased FIV and FEV in both smokers and relapsers, while pulmonary function was normal in non smokers. Significant differences between the groups exist regarding health history, beta carotene, health risks unrelated to smoking, and some important environmental exposures. Eating patterns varied among the 3 groups, with former smokers most aware of their nutritional intake. Smokers, as a group, weighed less and consumed fewer calories. Family and personal smoking history was shown to influence smoking behavior.

PURIFICATION OF ATRIAL DIPEPTIDYL CARBOXYHYDROLASE (ADPCH). Dulce F. Soler\* and Robert B. Harris, Dept. Biochem., Va. Commonwealth Univ., Richmond, VA 23298. ADPCH, a zinc-metallo proteinase isolated from atrial tissue, readily converts atriopeptin II to atriopeptin I and with particular substrates, also acts as a tripeptidyl carboxyhydrolase. The enzyme has now been purified to near homogeneity using PEG precipitation, anion-exchange, gel filtration, FPLC anion-exchange and lectin affinity chromatographies. Two pools of enzyme activity (hydrolysis of synthetic fluorogenic substrates) can be distinguished by their different adsorption behavior on FPLC anion-exchange and concanavalin A chromatographies; one enzyme pool adsorbs quantitatively to both matrices but the second does not bind to either matrix. The two enzymes are also differentially inhibited by 1(S)-carboxy-5-aminopentyl-L-Phe-L-Gly and show different efficiencies of catalysis of atriopeptin II. Both enzymes, however, are further distinguished from angiotensin I-converting enzyme, a ubiquitous zinc-dipeptidyl carboxyhydrolase. It is likely that the two enzymes represent charge isozymes of ADPCH.



**IDENTIFICATION OF CANDIDATE NON-A, NON-B HEPATITIS PROTEINS.** Amy Stinnett and Guy Cabral. Department of Microbiology and Immunology, Medical College of Virginia, Virginia Commonwealth University, Richmond, VA 23298-0678. Non-A, non-B (NANB) hepatitis accounts for 90% of the cases of post transfusion hepatitis in the United States. The etiologic agent of this disease has yet to be isolated and cannot be grown in tissue culture. The infectious agent is present in the blood of infected individuals since serum from infected patients can be used to infect chimpanzees, the only animal model for this disease. In the present study, virus positive serum was concentrated by ultracentrifugation, solubilized in an SDS solubilization buffer, and subjected to SDS 2-dimensional gel electrophoresis. Following electrophoresis, the gels were stained with silver. Duplicate gels were subjected to Western electrophoretic transfer and incubated with convalescent human NANB antiserum. This analysis has revealed four candidate NANB hepatitis associated proteins of relative mw/pl coordinates 40kD/5.9, 68kD/7.3, 49kD/7.2, 22kD/7.3. Two of these proteins appear to be hyperproduced in the disease state. One candidate protein, relative mw/pl coordinates 22kD/7.7, appears to be specific for the NANB hepatitis agent. Studies are in progress to confirm the specificity of the candidate proteins for non-A, non-B hepatitis.

**EFFECT OF OXYGEN-DERIVED FREE RADICALS ON THE SARCOPLASMIC RETICULUM  $\text{Ca}^{++}$ -ATPASE OF VASCULAR SMOOTH MUSCLE.** Yuichiro Suzuki\* & George D. Ford, Dept. of Physiology, Va. Commonwealth Univ., Richmond, Va. 23298. Spectrophotometric assay and computer simulation were used to investigate the effects of oxygen-derived free radicals on the activity of the sarcoplasmic reticulum  $\text{Ca}^{++}$ -ATPase of bovine aorta. An enriched small sarcoplasmic reticulum fraction was prepared and  $\text{Ca}^{++}$  sensitive activity of the ATPase was measured by following the decrease in NADH in the presence of excessive pyruvate kinase and lactic dehydrogenase. Superoxide anion radicals were generated by xanthine oxidase catalyzed oxidation of hypoxanthine. Hydroxyl radicals were generated by iron catalyzed homolytic fission of hydrogen peroxide. Superoxide anion radical, hydrogen peroxide, and hydroxyl radical all inhibited the  $\text{Ca}^{++}$ -ATPase activity in concentration dependent fashion, however, only superoxide anion radicals and hydroxyl radicals showed physiologically significant inhibition. Cysteine protected the  $\text{Ca}^{++}$ -ATPase from inhibition by superoxide anion radicals, suggesting that sulfhydryl groups may be involved in the mechanism. Network thermodynamic modeling was used to simulate the oxygen-derived free radical system to estimate the concentrations of radicals generated.

**AFFINITY OF BENZOMORPHAN ANALOGS FOR PCP AND MU OPIATE RECEPTORS.** Sherrill L. Todd\*, R.L. Balster, B.R. Martin, Pharmacol. & Toxicol., MCV/VCU, Richmond, VA 23298. The enantiomers of  $\beta$ -cyclazocine have previously been evaluated in a PCP drug discrimination paradigm (Slifer and Balster, JPET 244: 606, 1988). The isomers exhibited a large amount of stereoselectivity, and the (-)-isomer had very potent PCP-like effects. It was postulated that these compounds might be useful in separating the PCP and opiate-like effects of the benzomorphans. In the present study, these compounds and  $\beta$ -pentazocine isomers were evaluated for PCP and opiate binding activity. The PCP binding was conducted by incubating  $^3\text{H}$ -TCP (1nM) with rat brain membranes in 5 mM Tris buffer for 20 min at 25 °C. The  $\mu$ -opiate assay was conducted by incubating  $^3\text{H}$ -DAMGO (1nM) with rat brain membranes in 50 mM Tris buffer for 2.5 hrs at 30 °C. The affinity of (-)- $\beta$ -cyclazocine was 1.5-fold greater than PCP for the  $^3\text{H}$ -TCP binding, whereas (-)- $\beta$ -pentazocine, (+)- $\beta$ -cyclazocine, and (+)- $\beta$ -pentazocine were 18-, 206- and 454-fold less potent, respectively. In the DAMGO assay, (-)- $\beta$ -cyclazocine ( $K_d$ =15 nM) was 6.5-, 403- and 560-fold more potent than (-)- $\beta$ -pentazocine, (+)- $\beta$ -cyclazocine, and (+)- $\beta$ -pentazocine, respectively. These data correlate with that obtained in the drug discrimination where (-)- $\beta$ -cyclazocine was 5-fold more potent than PCP and 57-fold more potent than (+)- $\beta$ -cyclazocine. These data do not show a clear separation of PCP and  $\mu$ -opiate effects, but they may prove useful as receptor probes. (Supported by VA Commonwealth Ctr on Drug Abuse and NIDA DA 02396)

**A STABILITY STUDY OF ANTICANCER DRUGS BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY.** Bao-Ling Tsay and Lloyd Wolfinbarger, Jr., Ctr. for Biotechnology, Dept. Of Biological Sciences, Old Dominion University, Norfolk, VA 23529. A stability-indicating high-performance liquid chromatographic assay has been used to investigate the stability of solutions of melphalan under conditions that pertain to establishing in-vitro toxicity assays. The hydrolysis of melphalan in distilled water, cell culture medium, and bovine serum albumin at 37°C has been studied. Degradation of melphalan proceeded via monohydroxy melphalan to dihydroxy melphalan. Melphalan is completely hydrolyzed in water at 60°C after 2 hrs. At lower temperature, hydrolysis proceeds at slower rates. The presence of bovine serum albumin retards hydrolysis of melphalan in water. The melphalan hydrolysis rate is directly related to the bovine serum albumin concentration.

**PURIFICATION OF ATRIAL GRANULE SERINE PROTEINASE.** Donna M. Wypij\* and Robert B. Harris, Dept. Biochem., Va. Commonwealth Univ., Richmond, VA, 23298. Atrial granule proteinase catalyzes the formation of bioactive atrial natriuretic factor (ANF) from pro-ANF. The enzyme has been purified to homogeneity from isolated atrial granules using anion-exchange, gel filtration, and FPLC weak anion-exchange chromatographies. The apparent molecular weight of the enzyme increases with purification; in the atrial granule subcellular fraction, the  $M_r \approx 67,000$ , while in higher purity preparations, the  $M_r > 650,000$ . However, SDS-PAGE analysis with silver staining reveals a single major protein band,  $M_r \approx 75,000$ . The change in molecular weight can likely be attributed to non-covalent association of enzyme monomers during purification. In  $\leq 30\text{mM CaCl}_2$ , the enzyme is activated nearly 3-fold and, consistent with the idea of the enzyme being a calcium dependent neutral pH serine proteinase, it is adsorbed quantitatively to benzamidine-, Lys-, or Arg-Sepharose,  $\text{BaSO}_4$ , and heparin-agarose. This enzyme is inactive in the intragranular environment; processing likely takes place immediately prior to secretion of ANF.

## Microbiology

**MICROAEROPHILIC BACTERIA IN GROUNDWATER AND DEEP SUBSURFACE SOILS.** ROBERT E. BENOIT and TOM PHELPS\*. Dept. of Biol., VPI & SU, Blacksburg, VA. 24061. and Institute for Applied Microbiology, Univ. of Tennessee, Knoxville, TN. 37932. Groundwater and deep subsurface soils have a significant microbial biomass. The most abundant species isolated from these habitats were heterotrophic, procaryotic, aerobic bacteria. It was our hypothesis that a significant portion of this group consisted of microaerophilic bacteria. To prove the hypothesis, bacteria were isolated by oligotrophic plate count procedures using groundwater or subsurface soils as the inoculum. Semi-solid medium was used to screen isolates. Ten - twenty percent of the bacteria isolated from the water in a Virginia well were microaerophilic. Subsurface soil from a Savannah River site in South Carolina was obtained by rigorously controlled drill rig procedures. At least 10% of the subsurface bacteria isolated from the 463 M depth were microaerophils.



IMMUNODOMINANT ANTIGEN OF ACTINOBACILLUS ACTINOMYCETEMCOMITANS Y4 IN HIGH RESPONDER PATIENTS. Joseph V. Califano\*, Harvey A. Schenkein\*, John G. Tew, Dept. of Micro./Immuno. MCV/VCU, Richmond, Va. 23298 This study was undertaken to look for characteristics of the immunodominant antigen(s) of *Actinobacillus actinomycetemcomitans* (AaY4) that might help explain the high antibody titers in periodontitis patients. Radioimmunoassays (RIA) were performed on sera from 481 patients and 32 patients with the highest anti-AaY4 titers (above 128,000 RIA units/ml) were further analyzed. AaY4 antigen was boiled for 45 minutes or treated with papain and antibody responses were analyzed by RIA and western blots. In addition, AaY4 carbohydrate was purified from AaY4 and examined on western blots. The results indicated that the immunodominant antigen of AaY4 in high responders was stable after papain treatment or boiling for 45 minutes. Papain or boiling eliminated protein bands while a large diffuse band persisted in western blots. With increasing dilutions of sera, bands on western blots corresponding to protein antigens disappeared, while the large diffuse band resembling carbohydrate persisted. Partially purified AaY4 carbohydrate contained the large diffuse band. Double immunodiffusion analysis indicated that rabbit serotype b specific antiserum and patients' sera recognize the same antigen. The immunodominant antigen of AaY4 in high responder individuals appears to be a carbohydrate and is possibly the capsular polysaccharide.

A KINETIC HAIRPIN TRANSFER MODEL FOR PARVOVIRAL DNA REPLICATION. K.C. Chen, J.J. Tyson, M. Lederman, E.R. Stout and R.C. Bates. Dept. of Biol., VPI & SU, Blacksburg, VA 24061. Parvoviruses are small animal viruses that contain a linear single-stranded DNA genome with short palindromic sequences at each end. The sequence at each terminus is heterogeneous, consisting of two alternative reverse complementary sequences ("flip" or "flop"). The DNAs encapsidated by different parvoviruses show distinctly different patterns with respect to the ratio of plus-to-minus strands and the ratios of flip-to-flop conformations at each terminus. A hairpin transfer mechanism, which can explain the occurrence of flip and flop sequences, was proposed for the replication of parvoviruses. By invoking different rate constants for hairpin transfer at the termini, we have developed a unitary model which accounts for the observed virion DNA distribution of all parvoviruses. Our model also predicts the strand polarity and distribution of terminal conformations of the progeny of chimeric bovine parvoviruses constructed by recombinant DNA techniques.

BIODEGRADATION OF TERTIARY BUTYL ALCOHOL IN PRISTINE SUBSURFACE SOIL BY AN INTRODUCED PSEUDOMONAS SPECIES. JOHN J. EICHENBERGER, R. E. BENOIT, Dept. of Biol., Va. Polytechnic Inst., Blacksburg, Va. 24061. Tertiary butyl alcohol (TBA) is an important groundwater contaminant. Several studies have shown that TBA is a recalcitrant organic compound in habitats such as deep subsurface environments. This study utilized subsurface microcosms to evaluate the potential of a TBA degrading *Pseudomonas* sp. to affect TBA degradation in soil previously unexposed to hydrocarbons. The rate of TBA degradation was enhanced at low (10 mg/l) and high (500 mg/l) concentrations by the introduction of the *Pseudomonas* sp. to sterilized and nonsterilized controls. At intermediate concentrations (250 mg/l), the indigenous microflora degraded TBA at the same rate as the soil inoculated with the *Pseudomonas* sp.. TBA degradation has not been observed in some soils still under study. A current experiment is determining if TBA degradation is affected by the addition of simple organic amendments.



MICROENVIRONMENTS AS A FACTOR IN DETERMINING THE ABUNDANCE OF ANTIMICROBIAL-PRODUCING BACTERIA IN ESTUARINE WATERS. Linda L. Gilmer and A. S. Gordon, Dept. of Biol., Old Dominion University, Norfolk, VA.

Estuarine microenvironments in the lower Chesapeake Bay were investigated for the abundance and ecological distribution of antimicrobial-producing bacteria. Samples were taken from the water column, fish skin, and algal surfaces. There were 1472 bacteria isolated and assayed for antimicrobial activity against fungal, Gram(-) and Gram(+) bacterial test organisms. Of the total bacteria isolated and assayed, 5.2% were active antimicrobial-producers. Active cultures from the algal surfaces made up 75% of the total active cultures. The active cultures from the water column made up 15% and active cultures from the fish skin made up the remaining 10%.

NEW SUPERNATANT PROTEINS INDUCED IN RESPONSE TO COPPER IN *VIBRIO ALGINOLYTICUS*. V. Harwood-Sears and A.S. Gordon, Dept. of Biological Sciences, Old Dominion University, Norfolk, Va. 23508. Supernatants from copper challenged and control *Vibrio alginolyticus* cultures were compared to supernatants from heat shocked cultures (raised from 30°C to 42°C for 10 minutes). Chloramphenicol was added to some cultures before the addition of copper and before heat shock treatment. SDS-PAGE revealed a 21 kD protein unique to supernatants of copper challenged bacteria that was preferentially concentrated by immobilized metal ion affinity chromatography (IMAC). A 15.5 kD band common to heat shocked and copper challenged supernatants was also identified. These bands were not present in chloramphenicol-treated culture supernatants, indicating that they are the result of *de novo* protein synthesis.

These data strengthen the argument that the 21 kD protein is not a non-specifically induced stress protein, and that its primary function is complexation and detoxification of copper, and possibly of other metals as well.

MIGRATION OF GERMINAL CENTER B CELLS IN RESPONSE TO CHEMOATTRACTANT(S). Leo I. Kupp\*, John G. Tew, Harvey A. Schenkein\*, and Marie H. Kosco\*, Va. Commonwealth Univ., Richmond, VA 23298. The presence of chemoattractant(s) in sites of inflammation may explain why activated B cells and plasma cells accumulate in these sites. Previous studies with mice indicate that by 3 days post-immunization the lymph nodes swell and germinal center (GC) B cells leave the nodes. These experiments investigated whether GC B cells from actively immunized mice are attracted to factors in zymosan activated sera (ZAS). BALB/c mice were immunized with ovalbumin. On day 3 (and various other days) after secondary boost the draining lymph nodes and blood were harvested. The GC B cells were isolated, and both mouse and human sera were activated with zymosan. Boyden chambers with 8  $\mu$ m pore size filters were prepared in triplicate, incubated for 3 hr, and the distance the cells migrated determined. The greatest migration of cells occurred between 2-4 days with a peak at day 3. The results demonstrate a significant difference between control values and both types of activated sera with day 3 GC B cells ( $p < .001$ ); 1) Control 22  $\mu$ m  $\pm$  3; 2) mouse ZAS 59  $\mu$ m  $\pm$  5; and 3) human ZAS 79  $\mu$ m  $\pm$  8. Also, human ZAS values returned to control levels with the addition of 8.0  $\mu$ g of a rabbit anti-human C5 antibody (25  $\mu$ m  $\pm$  2;  $p < .001$ ). The checkerboard assay demonstrates that the migration observed is chemotactic. The data indicate that GC B cells have the property of chemotaxis toward a C5-derived peptide. This is the first report of normal B cells being capable of chemotaxis. This study was supported by NIH Grants DE 00151 and DE 08972.

PROBING PROTEIN:DNA INTERACTIONS IN INITIATION OF BACTERIOPHAGE P2 LATE GENE TRANSCRIPTION. Te-Chung Lee<sup>\*</sup> & Gail E. Christie<sup>\*</sup>, Dept. of Microbiol. & Immunol., Va Commonwealth Univ., Richmond, VA 23298. The coliphage P2 *ogr* gene encodes a positive regulatory protein essential for phage late gene transcription. P2 late transcription initiates at sites that differ in nucleotide sequence from those normally recognized by *E. coli* RNA polymerase. In order to study the mechanism of positive control by Ogr, we have purified Ogr protein and begun to characterize interactions between Ogr, the host transcription machinery, and the P2 late gene *P* promoter. No complex formation can be seen between the 110 bp *P* promoter fragment and purified Ogr or *E. coli* RNA polymerase. Specific RNA polymerase-promoter interactions are not observed even in the presence of Ogr, as assayed by a gel mobility shift and purified *in vitro* transcription. However, the gel mobility shift assay performed with the addition of crude cell extracts reveals formation of protein-promoter complexes which can then be specifically recognized by Ogr. This observation is further corroborated by *in vivo* footprinting analysis using dimethyl sulfate as a probe, which reveals altered methylation of bases induced upon occupation of the *P* promoter by the cellular transcription machinery and Ogr protein. The implication of these observations will be discussed.

NUCLEOTIDE SEQUENCE OF THE *ermFU* DETERMINANT AND ITS UPSTREAM FLANKING DNA. Susan Manning<sup>\*</sup>, Madelon Halula<sup>\*</sup> and Francis L. Macrina, Department of Microbiology and Immunology, Va. Commonwealth Univ., Richmond, Va 23298-0678. *Bacteroides fragilis* V503 carries the conjugative transposon, Tn5030. Southern blot hybridization studies of Tn5030 sequences revealed that the clindamycin resistance gene carried by this element was related to the *ermF* and *ermFS* genes found on two other *Bacteroides* transposons. The clindamycin resistance gene of Tn5030 was cloned and its nucleotide sequence has been determined. The gene has been designated *ermFU* and is quite similar to the *ermF* and *FS* sequences. *ermFU* differs from *ermF* and *FS* at 12 different nucleotide positions. These 12 single base changes result in 8 amino acid changes in the *erm* gene product, a ribosomal methylase enzyme. The *ermF* and *FS* genes have been shown previously to be adjacent to an insertion sequence (IS) element which provides the genetic signal for their transcription. Sequences upstream of the *ermFU* structural gene did not reveal such an IS element. Moreover, the *ermFU* upstream sequences gave rise to theoretical mRNA molecules with 5' secondary structure suggestive of cognate regulatory elements known to occur with *erm* genes from a variety of gram positive organisms. We conclude that the *ermFU* determinant has evolved in *Bacteroides* via a different process as compared to *ermF* and *FS*.

FRUCTOSE INDUCED DARK GERMINATION OF *ANABAENA* AKINETES. Deborah L. Neely-Fisher, Dolan M. Smith Jr., & Robert W. Fisher. Department of Biology, Virginia Commonwealth University, Richmond, Va. 23284-2012. Single-celled, axenic akinetes from *Anabaena variabilis* and *Anabaena azollae* were incubated on BG-11 medium supplemented with 1% Bacto-agar. Three different sources of combined nitrogen: KNO<sub>3</sub> (5 mM), NH<sub>4</sub>Cl (5 mM), and glutamine (5 mM), were added singly or in combination with fructose (50 mM) to the BG-11 plates. The akinetes were incubated under continuous light (5,500 lux) or in the dark at 25 ± 2 C. Akinetes of both species germinated in the light. Akinetes would not germinate in the dark unless the BG-11 was supplemented with fructose. Akinetes incubated in the dark on plates containing NH<sub>4</sub>Cl and fructose germinated less than those germinated in the presence of fructose alone. Preliminary experiments indicate that the dark germination of the akinetes may be affected by storage conditions. Akinetes stored in the light germinated (83%) to a higher level than those stored in the dark (35%) (Supported by NSF DMB 85-11770 and AID DPE-5542-G -SS-6021-00).



BONE MARROW ENHANCED ANTIBODY PRODUCTION BY GERMINAL CENTER (GC) B LYMPHOCYTES. R.M. Piazza\*, M.K. Kosco\*, A.K. Szakal\*, and J.G. Tew, Dept. of Micro/Immuno., MCV/VCU, Richmond, VA 23298. After antigen boost, GC B cells appear to leave the GC as they mature into plasma cells. Since the bone marrow (BM) is the major site of antibody production in the secondary response, we sought to determine if GC B cells travel to the BM as they mature and if the BM enhances antibody production. Day 3 peripheral blood cells were stained with the GC B cell marker peanut agglutinin (PNA) and the supernatants were assayed for specific antibody using a RIA. PNA+ cells in the blood produced antibody indicating that day 3 GC B cells were leaving the node and traveling via the blood to other sites. To determine if the BM could enhance their antibody production, GC B cells were isolated and cultured with BM, thymus or spleen cells. The GC B cells showed a dramatic increase in antibody production when cultured with BM, but not thymus or spleen cells. This enhancement was also seen when the GC B cells were immunized to an unrelated antigen, and could be induced by naive or immunized BM cells or by cell-free BM supernatants. The results suggest that GC B cells leave the lymph node and go to the BM. There, the BM constitutively produces hormones which enhance antibody production by GC B cells. The GC B cells may be the precursors of the plasma cells in the bone marrow, the major site of Ig production in the secondary immune response. NIH AI 17142

ORDER OF ADDITION OF SUGARS IN THE SYNTHESIS OF THE POLYSACCHARIDE CAPSULE OF CRYPTOCOCCUS NEOFORMANS. Catherine W. White, Dept. of Biochemistry, MCV-VCU, Richmond, VA 23298 and Eric S. Jacobson, Dept. of Medicine, MCV-VCU, Richmond, VA 23298 and Research Service, McGuire V. A. Med. Ctr., Richmond, VA 23249. Evidence for addition of glucuronic acid (GlcA) before xylose (Xyl) in biosynthesis of glucuronoxylomannan (GXM), a long mannan with GlcA and Xyl residues attached at regular intervals, comes from glycosyltransferase assays and from investigations of lipid-linked intermediates. Tremella mesenterica GXM which has been dexylosylated served as acceptor for Xyl. Dictyophora indusiata acetylmannan served as acceptor for GlcA but not Xyl which suggests that GlcA is appended first. In experiments looking for lipid-linked intermediates, when the incubation mixture included GDP-Man, UDP-(<sup>14</sup>C)GlcA and GDP-Xyl; UDP-Man, UDP-GlcA and UDP-(<sup>14</sup>C)Xyl; or GDP-Man and UDP-(<sup>14</sup>C)GlcA, no radioactive monosaccharide lipid-linked peak was detected, but with GDP-Man and UDP-(<sup>14</sup>C)Xyl such a peak was consistently observed. Since the reaction transferring sugars from lipid-linked compounds is reputed to be extremely rapid, this result is consistent with lipid-linked Xyl being formed but not being able to be transferred because of lack of GlcA, suggesting again that GlcA is appended to the polysaccharide first.

## Psychology

STRESS AND PERCEIVED SOCIAL SUPPORT: EFFECTS ON PERFORMANCE AND AFFECT. Jonathan M. Balcerek, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23508. The relationship between perceived social support and stress, and this relationship's effects on affect and task performance were examined. Subjects were informed that they were either to present a speech while being videotaped (high stress) or outline a speech (low stress). They were also told that they were to do this alone (low social support) or with a partner (high social support). Subjects then completed cognitive performance measures and affect ratings. It was hypothesized that high stress would lead to lower performance and higher negative affect scores, and perceived social support would lead to higher performance and lower affect scores. Five 2 (High vs. Low stress) X 2 (High perceived social support) X 2 (Males vs. Females) ANOVA's were performed on the dependent measures. A significant main effect for stress was found with the affect measures in the predicted direction. A significant difference was discovered for the social support conditions with the hostility rating. Implications of the results and the need for further research are discussed.



IDENTIFYING DECISION-MAKING VARIABLES USED BY DUAL-CAREER COUPLES: A MILITARY SAMPLE. Margaret K. Conrad, Dept. of Psych., Old Dominion University, Norfolk, Va. 23529-0053. This study identifies 23 variables used by dual-career couples when making decisions. Forty dual-career military spouses participated in a questionnaire survey. The survey consisted of open-ended questions for determining decision-making variables, as well as a Job Satisfaction Survey and Dyadic Adjustment Scale. The findings suggest there are no significant relationships between stratum groups, officer and enlisted, or gender groups, male and female, on either the Job Satisfaction Survey or Dyadic Adjustment Scales. However, there are significant relationships between gender and three of the decision-making variables and between stratum and four of the variables. A number of questions are raised for future research.

FACTORS INFLUENCING WEIGHT LOSS AND GAIN AMONG FRESHMAN AT VMI. Gerald N. Damron, Dept. of Psychology, Virginia Military Institute, Lexington, VA 24450. (Sponsor: T. L. Davidson). Freshman at Virginia Military Institute are exposed to a rigorous system of physical and mental training. For many cadets, one consequence of this training is substantial weight change (gain or loss). The present study attempted to identify factors that produce such changes. The subjects were 33 cadets who were chosen because they gained (N = 18) or lost (N = 15) at least 9 lbs during their first semester. A questionnaire was used to obtain information on physical condition, diet, stress level during the first semester. Information on body weight was obtained from the physical education department. The results showed that physical condition was correlated with body weight change. Cadets in poor condition tended to lose weight while those in good condition tended to gain weight. In general, diet and stress level were unrelated to body weight change. However, cadets who gained weight tended to snack more indicating greater intake and tended to think more about leaving VMI during their first semester, suggesting higher stress level.

MEASURING PANIC IN NONCLINICAL POPULATIONS: USE OF THE PANIC ATTACK QUESTIONNAIRE. Edwin A. Deagle III, & Timothy A. Brown\*, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23529-0267. Several recent studies have reported a high prevalence of panic in the general population. Most studies of this nature have used paper-and-pencil, self-report measures such as the Panic Attack Questionnaire (PAQ) to assess panic. The PAQ and the Anxiety Disorders Interview Schedule (ADIS) were administered to 98 college students to determine the concordance of these two measures. Consistent with previous studies using the PAQ, 26.5% of the sample reported last year panic. Using the ADIS interview, 31.6% of the sample reported last year panic. Whereas interrater agreement on the ADIS was quite high (93.5%), a concordance rate of only 61.1% was found between the ADIS and the PAQ. Results are discussed as they pertain to difficulties in assessing panic in nonclinical populations.

EFFECTS ON THE REA USING A DUAL TASK METHODOLOGY AND ATTENTIONAL MANIPULATION. Tina DiPalo, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23529. Effects of attention on the right ear advantage (REA) in a dichotic listening paradigm were examined during the simultaneous performance of a dichotic listening and a spatial processing task. The attention manipulation was enforced by instructing the subjects to attend either to their left or right ear. The results indicated the reaction times did not differ as a function of ear to which the subject was told to pay attention. Evidence also indicated that there were no differences between hand used in the spatial processing task. A main effect for level (single or dual task) was found to be significant, but no other effects were found. The findings in this study suggest that attending to one ear in a dichotic listening task is relatively easy, even if the subject is performing another task simultaneously.

COURTSHIP IN THE PERSONAL ADS: CHARACTERISTICS AND RESULTS OF SOUTHWEST VA. FEMALE ADVERTISERS. Chet H. Fischer, Department of Psychology, Radford Univ., Radford Va. 24142. An important consideration for the 62 million single adults in the United States is how to pair with other appropriate singles who have similar interests, needs, educations, etc. Fischer (1987) randomly sampled women who placed personal ads in a Washington, D.C. metropolitan magazine. The results indicated that these women advertisers were considerably above average in education, employment, assertiveness and income. Of interest, is the Washington, D.C. sample representative of the majority of women who place personal ads or are there important regional differences between female ad placers? In order to answer this question, women who placed personal ads in a Roanoke-Salem, Virginia metropolitan area magazine were mailed questionnaires. The results indicate that the Roanoke-Salem female sample had strong similarities to the Washington, D.C. female sample. In addition, the Southwest Virginia women had significantly more professional jobs, rated themselves as more attractive and were more likely to find a partner than the Washington, D.C. woman. Advertising does appear to be a useful method for pairing with other appropriate singles.

THE EFFECT OF ATTENTIONAL FOCUS ON PERFORMANCE OF AN ENDURANCE TASK. Pamela Foust\* & A. V. E. Harris, Dept. of Psychology, Radford Univ., Radford, Va. 24142. Moderately active, nonelite female volunteers (N=22) performed on a leg extension machine in two separate experimental sessions. An internal focus, with performers focusing on the feelings in their legs, was used in one session and an external focus, focusing on a collage, was used in the other session. Analyses revealed that significantly more repetitions were performed when using the external or distraction focus than the internal focus, and questionnaire responses indicated that participants clearly preferred the external focus.

THE EFFECTS OF LOW CONCENTRATION ODORS ON EEG ACTIVITY AND BEHAVIOR. Esther M. Huffman, A. DeMartino, J. DeMarco, Tyler S. Lorig. Washington and Lee University, Lexington, VA 24450. Previous research has suggested that low concentration odors significantly affect central nervous system activity. The present study examined this hypothesis and tried to determine if the odor of galoxolide, a synthetic musk, present in undetectable concentrations, could affect cognitive abilities. Results of EEG analyses indicated that the distribution of EEG alpha activity differed as a function of odor concentration in low and no-odor conditions. Further testing showed subthreshold levels significantly interfere with subject's performance, producing a substantial time delay in task accomplishment. These results support the hypothesis that undetected odors play a role in CNS activities. Emphasis on the special effects of odor on the amplitude and latencies of event-related potentials revealed significant changes in P200 wave amplitude which was directly related with the strength of the odor. This finding provides further evidence that undetected odors do have a notable effect on brain activity.



DEVELOPMENT OF SPATIAL MEMORY. Debra Hurtt, & Michael McClung, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. Earlier research from the W & L laboratory has shown that destruction of the hippocampus in rats disrupts radial-maze performance on a place task but not on one that involves finding rewards associated with specific cues. Since the hippocampus is not supposed to be fully developed in humans until about age 5, young children should have more difficulty on place tasks than on cued ones. Accordingly, we tested 4-year olds and 7-year olds on a computer-generated radial maze game. All subjects performed both a place task, which involved discovering the places in which "smiley faces" were hidden, and a cue task, which involved determining the cues that specified the location of the smiley faces. Contrary to expectation, the younger children did not have more difficulty on the place task than on the cue task. In fact the older children seemed to have more difficulty on the place than cue task. Additional experiments involving more disparate age groups and a more difficult task are needed.

GENDER AND MODELING EFFECTS ON THE PERFORMANCE OF A COHORT. Rebecca Regan Keever, Dept. of Psych., Old Dominion Univ., Norfolk, Va. 23529. This investigation tested the hypothesis that in an ambiguous situation, a worker will observe and model a co-worker's level of performance. As prior research on social influence has been inconclusive regarding gender differences, gender effects were also examined. Eighty subjects, 40 males and 40 females, were randomly assigned to a male or female confederate modeling either a fast or slow work pace. A MANOVA was computed on the following dependent measures-quantitative performance scores, a manipulation check on work level modeled, attitude towards performance and towards co-worker. Findings confirmed that when faced with ambiguity, workers do observe others' performance level. However, a modeling effect for actual performance was not found. As hypothesized, no gender differences for overall performance were found. Interestingly, subjects with the female confederate worked harder. Preference for opposite sex co-worker confirmed a hypothesized difference in attitude towards dyad composition. Implications of these findings for social learning and influence are discussed.

ROLE OF DISTRIBUTED PRACTICE IN REMEMBERING SPATIAL LOCATIONS. Michael McClung, David G. Elmes, & Joseph B. Thompson\*, Dept. of Psychol., Washington and Lee Univ., Lexington, VA 24450. Previous work from our laboratory failed to find that distributed practice led to better retention of spatial locations than did massed practice. Distribution of practice was varied between trials in the earlier work. To make the spatial task similar to a verbal learning one, we varied distribution of practice within a trial. On a computer screen, subjects were exposed to the locations of letters that were hidden behind rectangles. A specific letter was presented once or it had massed or distributed repetitions. Following presentation the subjects had to indicate the letter that appeared behind each rectangle. In the two experiments using this task, distributed practice led to better retention than did massed practice.



**THE EFFECT OF FRIENDSHIP AND GENDER COMPOSITION OF DYADS ON PRODUCTIVITY.** Jennifer A. Mikulka, Dept. of Psychology, Old Dominion Univ., Norfolk, VA 23508. The present experiment examined the effect of dyad gender composition and friendship on productivity for 64 college students between the ages of 17 and 30. There were two experimental conditions factorially combined: (1) friend or non-friend members of a dyad and (2) the gender mix of the members of the dyads, both male, both female, or a mixed gender dyad. All dyads were required to perform a simple production task requiring simple motor skills. The task required subjects to fold paper to construct "moon tents". The number of "moon tents" each individual and dyad constructed in 10 minutes were tabulated to determine the individual and total productivity of the dyad. Each subject also rated the level of friendship for their dyad partner in terms of length of acquaintance, degree of liking, and how well they knew their partner. A 2 x 3 factorial anova of dyad productivity revealed no significant effects for either dyad gender composition or friendship, nor their interaction. However, a significant correlation was found for productivity and length of friendship,  $r(62) = .28$ ,  $p < .02$ . Also, there was a marginal correlation between sex and productivity for friends,  $r(29) = .32$ ,  $p < .03$ , with females tending to be more productive.

**THE "FUZZY" LANGUAGE OF PRESCRIPTION LABELS.** Tonya R. Mustard & A.V.E. Harris, Dept. of Psychology, Radford Univ., Radford, Va. 24142. Reading prescription labels on medication bottles is often confusing. If medication is taken incorrectly, it may have deleterious effects. Questionnaires containing authentic prescription labels were administered to college students to interpret. Results suggest that less than half of those surveyed interpreted the labels correctly. Confidence in responding seemed to be a function of correctness. Suggestions for alleviation of the problem were made.

**INTERNATIONAL EDUCATION AND PSYCHOLOGY.** James P. O'Brien, Div. of Social Sciences, Tidewater Cmty. Col., Virginia Beach, Va. 23456. Our nation is just beginning to realize that the world has fundamentally changed to one which is characterized not by American preeminence, but rather by intricate multinational scientific, technological, cultural, political, and economic complexities. Furthermore, these complex interactions now impact every American personally. The challenge to American educators is simply that each of us is responsible for preparing the leaders of tomorrow not merely to survive in this new world, but to prosper. Each discipline must support the massive widespread development of knowledge and skills required to familiarize our students with the reality of an interdependent world, and psychology can ill afford to be an exception. The simplest steps should be taken first, namely; (1) in areas of traditional content (e.g., history of psychology, cross-cultural studies, foreign sources of current theory, etc.), and (2) in emerging specific content areas (e.g., Japanese management theory, applications of psychology to specific problems in other cultures, psychological research in other nations, etc.). Then, units on topics such as aggression, childrearing, intelligence, etc. could be amplified to include information on differences among cultures. Topics should be treated with relevant maps to provide geographic referents for students.

**DIFFERENCES IN BODY-IMAGE OF BLACK AND CAUCASIAN STUDENTS.** Clifford E. Rucker, Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23508. Eighty-four black and caucasian undergraduate students in psychology from Old Dominion University and Hampton University took part in an experiment to examine the differences in body-image of college students. Body silhouettes ranging from thin to very heavy were used to assess perceptual measures of body-image. The Multidimensional Body-Self Relations Questionnaire (MBSRQ) was used to evaluate attitudinal perceptions of body-image of subjects. The Body Areas Satisfaction Scale (BASS) was used in determining body satisfaction in subjects. Results revealed that males had a more positive perception of body image than females. There were no significant main effects found for race.

THE LONG-TERM EFFECTS OF DIAZEPAM AND YOHIMBINE ON TEMPERATURE SENSITIVITY IN THE RAT. Amy C. Sapp, Dept. of Psychology, Washington & Lee University, Daniel E. Schnock and T. L. Davidson, Dept. of Psychology, Virginia Military Institute, Lexington, VA 24450. This study compared the effects of prior exposure to diazepam, a well-known anxiolytic, with those of yohimbine, a putative anxiogenic, on pain sensitivity in the presence and in the absence of a signal for shock. Three groups of rats ( $N = 8$ ) were injected with diazepam (5 mg/kg), yohimbine (1 mg/kg), or saline (0.9% NaCl) once a day for 10 days. Injections were then terminated 11 days prior to the beginning of Pavlovian fear conditioning, in which a tone signaled a mild shock. At the conclusion of fear conditioning, the rats were tested for latency of reflexive tailflick to a temperature stimulus in the presence and the absence of the tone. It was found that rats previously treated with diazepam had greater pain sensitivity in the absence of the tone than either yohimbine-pretreated rats or controls. The groups did not differ reliably with respect to either the acquisition or extinction of conditioned fear to the tone. The results indicate that increased pain sensitivity is a long-term effect of diazepam use. (Supported by National Institutes of Health Grant NS24944-01).

THE DEVELOPMENT OF PAVLOVIAN CONDITIONED INHIBITION FOLLOWING IBOTENATE AND ASPIRATION LESIONS OF THE HIPPOCAMPUS. Kelly D. Shifflett, Amy C. Sapp, and Leonard E. Jarrard, Dept. of Psychology, Washington & Lee University, and T. L. Davidson, Dept. of Psychology, Virginia Military Institute, Lexington, VA 24450. Our previous research showed that for rats the capacity of one stimulus to signal the reinforcement of another (i.e., conditioned facilitation) was disrupted by aspiration lesions, but not by more selective ibotenic acid lesions, of the hippocampus. The present research examined the effects of both lesions on the capacity of one stimulus to signal the nonreinforcement of another (i.e., conditioned inhibition). Aspiration and ibotenate lesioned rats were compared on a simple Pavlovian discrimination (e.g., tone +; clicker -) and on a conditioned inhibition problem in which a light signaled nonreinforcement of an auditory cue. Incidence of head-jerking (short, rapid movements of the head) indexed learning. Neither aspiration or ibotenate lesioned rats were disrupted, relative to controls, on either type of discrimination problem. The results suggested that conditioned inhibition and facilitation have different neural substrates.

CULTURAL DIFFERENCES IN CHILDREARING: A COMPARISON OF CHINESE-AMERICAN AND AMERICAN MOTHERS. Hui-Mei Tseng\* & Michelle K. Kelley\*, Dept. of Psyc., Old Dominion Univ., Norfolk, Va. 23508. To provide empirical data on cultural differences in childrearing practices, 74 middle-class American and Chinese-American mothers of 3- to 8-year-olds children completed two recently developed and validated parenting questionnaires; the Parenting Dimensions Inventory and the Childrearing Goals Questionnaire. Comparison of scale scores from the Parenting Dimensions Inventory showed cultural differences in childrearing practices. American mothers scored higher on sensitivity, consistency, nonrestrictiveness and nurtures; whereas Chinese-American mothers scored higher on physical punishment and yelling at the child. No significant culture main effect was found for childrearing goals. However, a main effect was found for child age. Both American mothers and Chinese-American mothers placed more emphasis on politeness, concern of others, originality, morality, intelligence, striving, effectiveness and emotion adjustment for older children (six to eight years old) than younger children (five years old and under).



FOOD DEPRIVATION-INDUCED ANALGESIA IN RATS: CROSS-TOLERANCE WITH MORPHINE? Charles A. Tujo, and Brian R. McKenzie, Dept. of Biology, and T. L. Davidson, Dept. of Psychology, Virginia Military Institute, Lexington, VA 24450. Our previous research indicated that food deprivation induces a naloxone-reversible analgesia in rats. The present experiment sought to determine if there was cross-tolerance between the analgesic effects of food deprivation and those of morphine. Three groups of rats ( $N = 8$ ) were either exposed to 24 hr food deprivation, injected with morphine sulfate (5 mg/kg), or injected with saline (0.9% NaCl) every other day over a period of 10 days. All rats were then tested for analgesia following injection of morphine. Latency of reflexive tail-flick to a temperature stimulus served as the index of analgesia with shorter latencies indicating less effect of (i.e., more tolerance to) morphine. Mean tail-flick latencies of both the morphine preexposed and the deprivation preexposed groups were shorter than those of controls. This indicated the development of tolerance to morphine in both the morphine and the food deprivation preexposed groups. The results suggest that food deprivation activates an endogenous opiate system.

A COMPARISON BETWEEN THE SOCIAL SUPPORT OF COMMUTER AND CAMPUS STUDENTS. Sarah E. Ware & Barbara Winstead\*, Dept. of Psyc., Old Dominion Univ., Norfolk, Va. 23529. The purpose of this study was to compare the perceived social support from family and friends of commuter and campus students. A total of 61 students from Old Dominion Univ. served as subjects. Subjects were administered a questionnaire consisting of the Perceived Social Support, Family scale; the Perceived Social Support, Friends scale; and three measures of psychological well-being. An analysis of variance indicated no significant differences between commuter and campus groups for the amount of perceived social support from family and the amount of perceived social support from friends. Males and females also displayed no significant difference on the amount of perceived social support from family and friends. Pearson product-moment correlations were calculated between the social support scales and the three scales measuring psychological well-being. It was found that for the campus group, social support from friends was inversely related with loneliness and social support from family was inversely related with depression.

## Statistics

THE TIME COURSE OF MORTALITY BY DISEASE CATEGORY FOR THE ACUTE CARE HOSPITALS. R. Clifton Bailey and George Kattakuzhy, Health Standards and Quality Bureau, Health Care Financing Administration, ME 2-D-2, 6325 Security Blvd., Baltimore, MD 21207. The Health Care Financing Administration used 16 disease categories in its publication of the hospital mortality rates for nearly 6,000 acute care hospitals. The published mortality rates for 30 days post admission were compared with mortality rates adjusted for age, sex, comorbidities, and prior admissions through a logistic regression model. This paper will evaluate the survival probabilities for the categories as a function of time. The modified Makeham survival model with a decreasing hazard is used to examine the survival time by category. The survival model with covariates is contrasted with the logistic model. It is noted that the survival model does not rely on the proportional hazards assumption.



**ROBUSTNESS OF NORMAL THEORY UMPIU TESTS FOR FIXED EFFECTS IN BALANCED MIXED ANOVA MODELS.** Robert M. Boudreau, Dept. of Mathematical Sciences, Va. Commonwealth Univ., Richmond, VA 23284-2014. In balanced mixed ANOVA models with fixed effects and normally distributed random effects, several authors have demonstrated that the usual F-tests for individual fixed effects are also uniformly most powerful invariant unbiased tests (UMPIU). Others have developed sufficient conditions through which it has been shown that these F tests are null robust (have the same distribution) in a larger elliptically symmetric class of distributions for the random effects. In this paper, a simpler set of sufficient conditions for a normal theory statistic to be null robust are given, in which only scale and location invariance need to be checked. The demonstration of null robustness of the F tests for fixed and random effects is greatly simplified. A recent attempt to extend UMPIU optimality of the F tests for fixed effects in balanced mixed ANOVA to models where the random effects have densities in a larger convex elliptically symmetric class is shown to be incorrect. Lastly, a proof is given showing that the F tests for fixed effects in balanced mixed ANOVA are null, nonnull, and UMPIU robust in a larger class of models where the random effects have elliptically symmetric densities. Convexity is not required. Convex but non-elliptical optimality is still an open question.

**REPEATED MEASUREMENT DESIGNS FOR 3N FACTORIALS WHEN HIGH ORDER INTERACTIONS ARE NEGLIGIBLE.** Chen-chi Shing, Dept. of Comp. Sci., Radford Univ., Radford, Va. 24142. Existing repeated measurement designs can be modified when the treatments have a 3n factorial structure and when high order interactions can be considered negligible under a fixed effects additive model. This can lead to a substantial reduction in the number of periods.

**MODELING THE LITTER SIZE DISTRIBUTION IN REPRODUCTIVE TOXICITY EXPERIMENTS.** Vernon M. Chinchilli, Dept. of Biostatistics, Va. Commonwealth Univ., Richmond, Va. 23298-0032. Developmental and reproductive toxicity experiments are conducted on laboratory animals (usually rodents) as a means of screening agents for deleterious effects on (1) fertility and reproductive performance, (2) fetal development, and/or (3) perinatal and postnatal development. The experimental design usually consists of pregnant female animals (dams) randomized to r+1 groups, in which the groups represent a vehicle control and increasing doses of the agent in question. The fetuses within a litter typically do not act independently of one another and any statistical analysis of fetal measurements needs to account for this "litter effect." This presentation examines binary measurements on fetuses in a random-sized litter via the general estimating equations of Liang and Zeger (1986, *Biometrika* 73, 13-22), in which only expressions for second-order moments are needed.

**PARALLEL AXES AS A DIAGNOSTIC TOOL.** Kathryn S. Dawson, C. Gennings, W.H. Carter, Dept. of Biostatistics, Va. Commonwealth Univ., Richmond, Va. 23298.

A visual representation of a functional relationship is often helpful in understanding the behavior of the function. When the dimensionality of the function exceeds 2 or 3 plotting techniques are often cumbersome. Plotting in the parallel axis system is a technique which, once the user learns to interpret the plots, offers a two dimensional presentation of a higher dimensional relationship. These plots can be used to detect trends or clusters in data. Higher dimensional confidence regions can be visualized. In particular a confidence region about model parameters can be used to detect collinearity using a general linear model. Once a confidence region is plotted an algorithm can be used to determine if a given point is within the region.

NONPARAMETRIC DISTRIBUTION ESTIMATION AND SMOOTHED BOOTSTRAPPING. Clark Gaylord and Donald Ramirez, Dept. of Math., Univ. of Va., Charlottesville, VA 22903. We determine the number of variable knots for computing a natural spline estimate of a cumulative distribution. Techniques to assure monotonicity are discussed. Using splines as a nonparametric distribution estimate, a comparison of bootstrapping and smoothed bootstrapping is given.

A FLEXIBLE TECHNIQUE FOR MODELING DRUG INTERACTIONS. Chris Gennings, Dept. of Biostatistics, Medical College of Virginia / Virginia Commonwealth Univ., Richmond, VA 23298-0032.

A semi-parametric model is developed for the representation of the joint action of mixtures of drugs. The model allows for monotonic transformations of the applied drug doses which approximates the dose/response metameter. In addition, the model estimates a cross-product term on these estimated metameters, thus allowing for departure from additivity and conditional inferences regarding the joint action of the drugs. One algorithm used for the estimation of the model is given and others are suggested. The procedure is illustrated with two examples. The first demonstrates logistic regression, and the second, poisson regression.

#### ESTIMATING FAULT HITTING RATES BY RECAPTURE SAMPLING.

Rajan Gupta and Larry Lee, Dept. of Math and Stat., Old Dominion Univ., Norfolk, Va 23529-0077. For the recapture debugging design introduced by Nayak (1988) we consider the problem of estimating the hitting rates of the faults remaining in a system. In the context of a conditional likelihood, moment estimators are derived and are shown to be asymptotically normal and fully efficient. Fixed sample properties of the moment estimators are compared, through simulation, with those of the conditional maximum likelihood estimators. Also considered is a procedure for testing the assumption that faults have identical hitting rates; this provides a test of fit of the Jelinski-Moranda (1972) model. It is assumed that the residual hitting rates follow a log linear rate model and that the testing process is truncated when the gaps between the detection of new errors exceed a fixed amount of time.

A CUMULATIVE BAYESIAN QUALITY CONTROL METHOD. John Joseph\*, Dr. Van Bowen, Dept. of Mathematics & Computer Science, University of Richmond, VA 23173. CUSUM control algorithms have been developed over the past decade to improve the intended use of Shewhart charts. This paper incorporates the same idea as the CUSUM technique, but uses Bayesian methods to accomplish the same objective. Tables are provided which allow the user to select the asymptotic expected run length required to detect a production mean drift of  $k$  standard deviations.

A NEW TEST FOR NON-NORMALITY USING ORDER STATISTICS. Sean Keller\*, Dr. Van Bowen, Dept. of Mathematics & Computer Science, University of Richmond, VA 23173. Using estimators for the mean of the largest sample value observed in  $k$  samples, a test is presented which has power greater than the Kolmogorov/Smirnov test for distributions which are heavier-tailed than the normal. The new test is also shown to detect mixtures distributions under special conditions.



COMPARISON OF ALTERNATIVE PREDICTORS UNDER AUTOREGRESSIVE MODEL WITH POLYNOMIAL TREND. Dayanand N. Naik, Dept. of Math. & Stat., Old Dominion Univ., Norfolk, Va 23529. Prediction of future observations in an autoregressive model with a polynomial trend is investigated. Several predictors are introduced and are compared using the mean square error of prediction (MSEP). Based on the analysis of data and simulation study it is concluded that, for small samples the predictors based on shrinkage type estimators for the regression parameters perform better than the usual predictors.

SIMULTANEOUS ESTIMATION OF GAMMA MEANS USING A HIERARCHICAL GENERALIZED LINEAR MODEL. Patricia A. Pepple, Department of Mathematical Sciences, Virginia Commonwealth University, Richmond, Va. 23284. The problem of simultaneously estimating  $p$  Gamma means is investigated when the means are believed a priori to satisfy an  $r$ -dimensional generalized linear model. Using a Bayesian hierarchical model to reflect the uncertainty in the linear model, approximate methods are proposed to compute the posterior densities. The resulting estimator shrinks the usual estimator toward a prior estimator where the size of the shrinkage depends upon the agreement of the observed data with the proposed generalized linear model.

ESTIMATION OF GROUP DELAY BETWEEN TWO TIME SERIES USING SMALL SAMPLES. Philip J. Ramsey and Robert V. Foutz, Dept. of Stat., VPI&SU, Blacksburg, VA, 24061. Time domain approaches to characterizing the time delay relationship between time series can result in overly complicated models. However, the time delay relationship in the frequency domain is always simple, irrespective of the complexity in the time domain. Unfortunately, the simple time delay relationship often changes for the various frequency components in the two time series. Frequency based time delay is often referred to as group delay and at present no satisfactory estimation method exists for group delay, with small data samples. The talk will consider a couple of candidate methods for estimating group delay.

ESTIMATION IN A NON-LINEAR PARTITIONED STRUCTURAL MODEL. Rana P. Singh, Department of Mathematics, Virginia State University, Petersburg, Virginia 23803.

In the reduced form of the general linear structural model, the parameter matrix is a non-linear matrix function of the partitioned matrix of the structural parameters. The aim of this paper is to present an expression for the asymptotic covariance matrix for the non-linear partitioned matrix functions. This result is then applied to derive the asymptotic covariance matrix of the non-linear matrix function of the partitioned matrix of structural parameters. These asymptotic expressions extend the approach followed by Neudecker [Statistica Neerlandica, 22, 69-82, (1968)] to partitioned situations.

EASYGRADE: A COMPUTER PROGRAM FOR GRADING STATISTICS PROBLEMS.

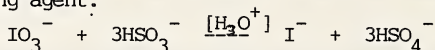
Robert S. Schulman, Dept. of Stat., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Tired of grading papers? Unhappy with currently available computer-scoring options, namely multiple choice questions? Welcome to EasyGrade! Written for the Macintosh computer, EasyGrade is a program that scores any numeric values, not just multiple guess questions. It is designed especially for statistics problems and handles a wide range of complexity from single numeric values to complicated anova tables or multiple range tests. And, of course, you can also use multiple choice items.



**OPTIMAL AND NEAR OPTIMAL SETS OF LATIN SQUARES FOR CORRELATED ERRORS.** Nizam Uddin\* and J.P. Morgan, Dept. of Math. and Stat., Old Dominion University, Norfolk, VA 23529. In this paper we consider the design problem in the row/column setting when the errors follow a second order autonormal process and more than one two-dimensional block is to be used. First universal optimality conditions are derived under the restriction that each layout be equireplicate. Then it is shown that the optimality conditions can be relaxed in such a way that the resulting designs still enjoy very high efficiency within the more general class unrestricted by the replication constraint. Constructions for these efficient designs are given.

## Poster

**KINETIC STUDY OF AN IODINE CLOCK REACTION.** John W. Barton, Dept. of Chem., Clinch Valley College, Wise, VA 24293, & Dr. Walter Crouse, Dept. of Chem., Clinch Valley College, Wise, VA 24293. The "iodine clock" in question involves the reaction of hydrogen sulfite ion,  $\text{HSO}_3^-$ , a reducing agent, with the iodate ion,  $\text{IO}_3^-$ , an oxidizing agent.



Research conducted over the past 3-4 months has included an examination of how the effective concentration of both anions, singly and together, control the rate of the reaction. The reaction order with respect to each reactant is being determined. The reaction is normally run with an excess of iodate ion present. The study has also looked at an unusual characteristic of the reaction--its severe pH dependence. At present, very little research has been conducted involving hydronium's effect on rate of reaction. The particular reaction being studied, different than most found in lab texts, is used frequently for kinetic studies in lower level chemistry labs at Clinch Valley College due to its ease of preparation and endpoint clarity. This project will enable us to understand better this iodine clock reaction for future use in all general chem. laboratories.

**A NUCLEAR (GUANINE-7-)METHYLTRANSFERASE ISOLATED FROM EHRLICH ASCITES CELLS,** Guojun Bu and Thomas O. Sitz, Department of Biochemistry, Virginia Tech, Blacksburg, VA 24061. An RNA(guanine-7-)methyltransferase has been partially purified from the nuclei of Ehrlich ascites cells. This enzyme at pH 8 bound to DEAE-Sephadex but did not bind to CM-Sephadex; at pH 7 it did bind to CM-Sephadex (the bound enzyme was eluted from both columns with about 0.15 M KCl). The substrate for this methyltransferase was methyl-deficient RNA isolated from the post-polysomal supernatant from mouse liver isolated from ethionine treated mice (M.D. post poly RNA). When the methylated RNA product was isolated and hydrolyzed with NaOH a fragment with a -5 charge was isolated, and when hydrolyzed with T2 RNase a fragment with a charge of about -4.5 was isolated. The 7-methylguanine purine ring opens at high pH and the positive charge at the 7-position is lost. After digestion with venom phosphodiesterase and alkaline phosphatase we identified 7-methylguanosine as the methylated component in the "cap" structure. Post-polysomal RNA from mouse liver was not a substrate, while post-polysomal RNA isolated from Ehrlich ascites cells had about half the methyl-accepting activity of RNA isolated from ethionine treated mouse liver. Therefore, in hypomethylated tissue we find non-methylated cap structures in RNA that serves as substrate for this methyltransferase. Commercial "cap" structures such as GpppN were inefficient methyl-acceptors for the (guanine-7-)methyltransferase.

CHEMISTRY IN OUR DAILY LIVES--A LABORATORY EXPERIENCE. Walter C. Crouse, Department of Natural Science, Clinch Valley College of the University of Virginia, Wise, Virginia 24293. General education requirements of Clinch Valley College include eight hours of laboratory science. I have recently developed a follow-up, nonmathematical course to our present introductory course for the non-science majors. The course's primary objective is to acquaint these students with the world of chemistry as it affects their daily lives: nutrition, food additives, cosmetics, household cleaning products, plastics and fibers, medicinal and addictive drugs, toxic substances, garden chemicals, energy production, and air and water pollution. The laboratory program supplements and supports the lecture material. The students prepare aspirin, face cream, face powder (with analysis), toothpaste, soap, polystyrene, and NPK-fertilizer. As part of the laboratory for each experiment, the students perform a cost analysis of the raw materials for comparison to the retail price of the commercial product. The students begin their laboratory experience by learning to read product labels for ingredient, safety, and nutritional information. They extract protein from milk (with characterization), dye fabrics, identify carbohydrates, study enzymatic breakdown of starch, determine chlorine level and pH of the CVC swimming pool, analyze antacid tablets, and demonstrate the effects of acid rain on the environment. The student's experiences and evaluations will be discussed.

ACANTHAMOEBA ISOLATED FROM FECAL PELLETS OF SOME WILD MAMMALS. Ralph P. Eckerlin, Natural Sciences Div., Northern Va. Cmnty. Col., Annandale, VA 22003, & Thomas K. Sawyer, Rescon Associates, Inc., Royal Oak, MD 21662. Small free living amoebae of the genus Acanthamoeba are well known inhabitants of soil and water but only recently have been recognized as agents of disease in man and other animals. Non-pathogenic strains of the amoeba are routinely isolated from clean soil and water while potentially pathogenic ones are commonly found in areas affected by sewage or thermal pollution. Little is known about the ecology of Acanthamoeba or the role of mammalian species acting as dispersal agents in the introduction of pathogenic Acanthamoeba into waters. Fecal pellets were obtained from 148 mammals of 10 species from pristine environments in VA and WV, USA. Five species of Acanthamoeba were isolated from 43% of the mammals. A. polyphaga (30%), and A. rhyssodes (7%) were the most common but A. hatchetti (3%), A. castellanii (1%) and A. lenticulata (1%) were also present. All but 2 isolates were not temperature tolerant and did not grow at incubation temperatures of 37-39°C and are therefore not potentially pathogenic. Further study of mammals from sewage polluted environments is indicated.

CANDIDATE POSTEMERGENCE HERBICIDES FOR SELECTIVE CONTROL OF PERENNIAL JOHNSONGRASS (SORGHUM HALEPENSE) IN CORN (ZEA MAYS). Chester L. Foy and Harold L. Witt, Dept. of Plant Path., Physiol. & Weed Sci., VPI & SU, Blacksburg, VA 24061. Johnsongrass, a coarse, tall growing grass that spreads by seed and strong rhizomes, is a serious problem in corn in many southeastern states including Virginia. Only EPTC and butylate applied preplant incorporated provide satisfactory control of seedling johnsongrass and suppression of rhizome johnsongrass. Three new postemergence herbicides, DPX-V9360, primisulfuron, and S-63596, were evaluated in no-tillage and conventional plantings. DPX-V9360 at rates of 35 (except in no-tillage plots), 52 and 69 g a.i./ha applied to 8-leaf johnsongrass was very effective. Primisulfuron at 25, 49 and 99 g a.i./ha was effective at the highest rate. Applications of these two herbicides to 6-leaf johnsongrass resulted in 69% or less control. S-63596 at rates of 99 to 173 g a.i./ha failed to provide lasting control, regardless of the stage of growth of johnsongrass, and caused serious early crop injury (yellowing, twisting, stunting). Minor injury occurred early with the other two herbicides. After 41 to 49 days, crop vigor in treated plots was comparable to or slightly better (some no-tillage plots) than in untreated plots. Both DPX-V9360 (Accent®) and primisulfuron (Beacon®) show promise and warrant further investigation.



A METHOD FOR INVESTIGATING THE VIABILITY OF YEAST USING HISTONE EXPRESSED FROM EXTRACHROMOSOMAL DNA, R.Hellams, Dr. P.Swerdlow(MCV) and Dr.B.Mittman, Biol.Dept., Univ.of Richmond, Va.23173. Wild type haploid yeast contain 2 copies each of the 4 core histones. We are examining whether yeast *Saccharomyces cerevisiae* with both chromosomal copies of the core histones made nonfunctional, can be rescued by a plasmid carrying wild type copies of the genes. A plasmid construct containing genes encoding tryptophan and histones H2A-H2B-H3-H4 will be transformed into yeast strain BAM200 which carries *ura3-52* and *trypl-289* mutations with deletions of both copies of H3-H4. BAM200 is surviving on plasmid pBAM8/476 copies of H3-H4. Uracil and tryptophan allow a tracking mechanism for each plasmid. A cell transformed with both plasmids will then be grown on media containing uracil but lacking tryptophan. pBAM8/476 carrying the uracil marker and H3-H4 genes is lost from the cell. BAM201 is then surviving on plasmid pRH1 which carries the tryptophan marker and the H2A-H2B-H3-H4 genes. We will then construct a yeast strain carrying defects in all chromosomal copies of the histone genes. To test whether pRH1 can rescue that cell, BAM201 will be crossed with a strain surviving on plasmid pTS101-2 encoding copies of H2A-H2B. The cell is then grown on media selecting for pTS101-2 loss. Sporulation, tetrad dissection and blot transfer analysis will identify a cell carrying nonfunctional chromosomal copies of the histones.

FOURIER-TRANSFORM INFRARED SPECTROSCOPIC STUDIES OF THE MEMBRANE PROTEIN CYTOCHROME B<sub>5</sub>. Peter W. Holloway, Dept. of Biochemistry, Univ. of Va. Sch. of Med., Charlottesville, VA 22908. We have recently completed some FTIR studies of cytochrome b<sub>5</sub> which was isolated from the endoplasmic reticulum membranes of rabbit liver. Spectra were obtained of the protein dissolved in buffers prepared either from D<sub>2</sub>O or H<sub>2</sub>O and the corresponding buffer blank was subtracted. The spectrum in H<sub>2</sub>O is characterized by two broad bands centered at 1650 and 1550 cm<sup>-1</sup>, these are the amide I and amide II bands, respectively. When the sample is dissolved in D<sub>2</sub>O, because of N-H to N-D exchange, both bands are shifted to lower frequencies. The residual spectral band which remains at 1550 cm<sup>-1</sup> is due to amino acid side chain COO<sup>-</sup>. The amide I band is a complex composite of several discrete bands that are characteristic of specific types of secondary structure and the broad band can be deconvolved into its component parts to enable structural assignments to be made. The evaluation of the spectra in the H<sub>2</sub>O versus D<sub>2</sub>O aids in these assignments and gives additional information as to the exposure of the peptide bonds to the solvent.

IN VIVO AND IN VITRO FERTILIZATION IN MOUSE UNDER THE INFLUENCE OF RU486. Subhash C. Juneja and Melvin G. Dodson\*, Dept. OB/GYN, Col. Med., East Tennessee State Univ., Johnson City, TN 37614. Two separate experiments were conducted to evaluate the effect of RU486 on fertilization in the mouse: 1) In Vivo Fertilization: Female mice (B<sub>6</sub>D<sub>2</sub>F<sub>1</sub>) were injected s.c. with RU486 (500 µg) daily for 4 days (8 mice) before superovulation with PMSG and HCG. There were 8 control mice. Females were caged individually with males after the HCG injection. The number of fertilized eggs (2-cell formation) as well as total number of eggs recovered from oviducts were significantly less in test animals compared to controls treated with vehicle only. RU486 injected mice produced an average of  $5.50 \pm 2.22$  fertilized eggs compared to  $28.76 \pm 13.20$  ( $\pm$ S.E.M.,  $P < 0.001$ ) from controls. 2) In Vitro Fertilization: Cumulus oophorus complex containing eggs were collected from superovulated mice at 14.5 h post-HCG and were inseminated in vitro with capacitated sperms and incubated for three hours in the presence of RU486 at different concentrations in culture media. RU486 adversely affected in vitro fertilization in the mouse at concentrations from 5 µg/ml to 20 µg/ml. Conclusion: 1) RU486 suppresses the ability of the mouse to superovulate with recovery of fewer 2-cell eggs. 2) RU486 adversely affects in vitro fertilization in the mouse.



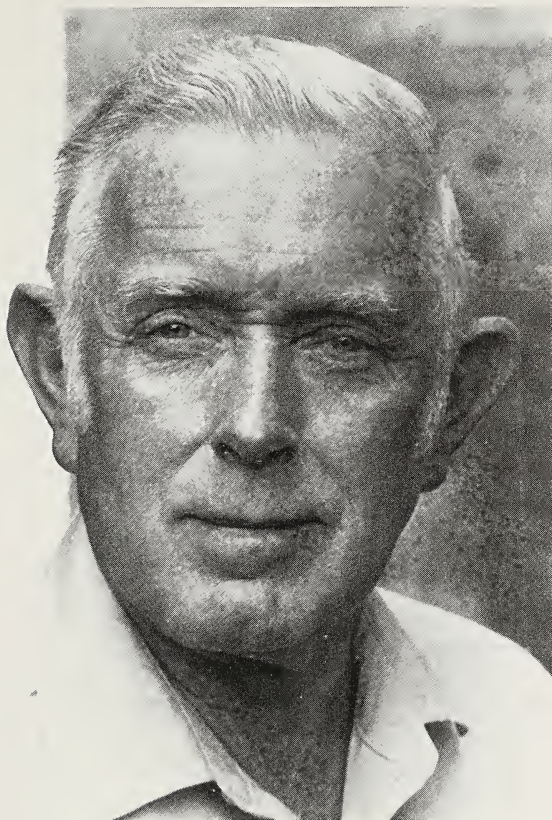
ROLE OF TERMINI IN BOVINE PARVOVIRUS DNA REPLICATION. J. B. Metcalf, S. F. Walk, M. Lederman, E. R. Stout and R. C. Bates. Dept. of Biol., Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. We are investigating the cis signals required for the replication of the single-stranded DNA genome of Bovine Parvovirus (BPV). The termini of BPV contain non-identical palindromes. In contrast, the parvovirus Adeno-Associated Virus (AAV) has identical palindromic termini. Previous studies have indicated that the cis signals for replication are located in the termini. To test this experimentally, we have constructed recombinant molecules which contain combinations of BPV termini but without BPV coding sequences. We have constructed other chimeric molecules that have the 5' or 3' terminus of BPV replaced with an AAV terminus. The ability of these molecules to serve as a replicon was assayed by cotransfecting bovine fetal lung cells with the chimeric molecules and a genomic clone of BPV to provide replication functions in trans. We have determined that recombinants containing just 300 nucleotides of the BPV 3' terminus and 250 nucleotides of the 5' terminus can be rescued and replicated. These molecules also inhibit BPV replication and, thus, act like defective interfering particles. BPV-AAV chimeras were only minimally rescued and replicated, if at all.

RELATIONSHIP BETWEEN INDOOR RADON AND WELL WATER RADON. Douglas G. Mose and George W. Mushrush, Center of Basic and Applied Science, George Mason University, Fairfax, VA 22030. A recently completed study of indoor radon and drinking water radon in Virginia and Maryland homes has identified two environmental concerns.

1. Indoor radon during 1987 and 1988 averaged about 4 pCi/l. It appears that
  - a. Winter indoor radon tends to be about 30% greater than summer indoor radon.
  - b. Basement indoor radon tends to be about 30% greater than first floor radon.
  - c. Indoor radon in homes with electrical heating systems tends to be about 25% greater than homes with combustion heating systems (mainly oil and gas).
  - d. Indoor radon in homes that have concrete block basement walls tends to be about 10% greater than in homes with poured concrete basement walls.
2. Radon in the drinking water of homes that use a private water well averages about 2000 pCi/l, and ranges from about 200 to 50,000 pCi/l. It appears that
  - a. Municipal water supplies in the study area do not contain measurable radon.
  - b. For any particular home size, indoor radon tends to be greater in homes that have more radon in the water supplied to the home.
  - c. For any particular amount of radon in the home water supply, the indoor radon increases as the size of the home decreases.
  - d. As the radon in the drinking water increases, the cancer rate increases.

SIGNAL PROCESSING OF SIMULATED, OCEAN BOTTOM INTERACTING, ACOUSTICAL SIGNALS. Steven Roberti, and Roddy V. Amenta, Dept. of Geol. and Geog., James Madison Univ., Harrisonburg, Va. 22807. Certain techniques of digital signal processing are important in modern seismology and marine acoustics. Education in the use of these techniques has been facilitated by the personal computer, and by the general availability of signal processing primitives (SPP) for performing operations such as fast Fourier transform, convolution, deconvolution cross-correlation, and filtering. Our recent efforts were directed toward creating a signal processing workstation on a PC computer which can also be used as an educational tool. We have developed a menu driven system to implement various signal processing operations using available SPP, Fortran drivers for these SPP and DOS batch files. A special feature of this system is that it allows for the simulation of defined signals, such as ocean bottom interacting signals, with or without added white noise. Signals with noise are being used to test performance of filters.

THE EFFECT OF CYCLOSPORIN A: AN IMMUNOSUPPRESSIVE AGENT ON *TRYPANOSOMA MUSCULI* IN SWISS WEBSTER FEMALE MICE. Dilip K. Sen, Hunter D. Hamlett and Rodney Higgs. Department of Biology, Virginia State University, Petersburg, Va 23803. This study reports the effects of Cyclosporin A (CsA) on *Trypanosoma musculi* development in Swiss Webster (SW) female mice. A total of fifty-two SW female mice weighing 25g - 30g were used. The control groups as well as the experimental groups were infected with a standard inoculum of 50,000 *T. musculi* per mouse on Day 1 of experimentation. Nine mice in Exp. I and 10 mice in Exp. II were injected with 250µg of CsA on Day 3 prior to inoculation of a standard inoculum of trypanosomes per mouse. Nine other mice in Exp. I and 5 animals in Exp. II were injected with 250µg of the drug CsA on Day 3 after trypanosome inoculation. Nine untreated mice in Exp. I and ten in Exp. II which were infected with the standard inoculum of *T. musculi* served as controls. Higher levels of parasitemia were observed in the drug-treated experimental mice in both experiments when compared to the untreated control counterparts. The timing of CsA administration appeared to be of significance in the observed effect. (Supported by the MARC Program Grant No. GM07678)



**Kenneth R. Lawless**

The Virginia Academy of Science has accorded Kenneth R. Lawless its highest honor by selecting him as a Fellow of the Academy. Dr. Lawless, Professor and former Chair of Materials Science in the University of Virginia's School of Engineering, was recognized for his many contributions to science and the Virginia Academy of Science.

In addition to his involvement in establishing the Universities's Department of Material Science and guiding it to a position as one of America's foremost scientific groups in electron microscopy, Dr. Lawless was lauded for his excellence as a teacher. Many of his former students are leading researchers in their fields.

In announcing the selection, VAS President Stewart A. Ware noted Dr. Lawless's service as President of the Academy in 1980, his Chairmanship of the Academy's Materials Science Section and his leadership and contributions to the Electron Microscopy Society of America and the National Institute for Dental Research. He has also received the Academy's most Prestigious honor for original research, the J. Shelton Horsley Award.

Dr. Lawless is a Fulbright Fellow and a member of Tau Beta Pi, The Raven Society and Phi Beta Kappa.





**Ivey F. Lewis Distinguished Service Award  
Ertle Thompson**

May 11, 1956 the first Distinguished Service Award made in the history of the Academy was presented to Dr. Ivey F. Lewis, Dean of the University of Virginia, who served as the first President of the Virginia Academy of Science. Dr. Lewis' citation was as follows: "Able investigator; master teacher, who with gentleness of manner, with kindness and understanding, has labored for the advancement of science and the welfare of mankind."

In keeping with the tradition and quality of service of the twenty-two recipients of the Ivey F. Lewis Distinguished Service Award since 1956, it is fitting for 1989 that:

Distinguished educator, academic statesman, and staunch supporter of the Virginia Academy of Science, Ertle Thompson is an obvious choice to be honored with the Ivey F. Lewis Distinguished Service Award of the Academy. His selfless devotion to his University, to the Commonwealth, and to the advancement of science provides us with a shining example of service for all to emulate.

Dr. Thompson has served in the trenches of science education. He has taught in the secondary schools of Buchanan County, at Clinch Valley College, and at the University of Virginia. He has been a leader in the promotion of science teaching through his work with the Association for the Education of Teachers of Science, serving as President in 1979-1980; with the National Science teachers Association Board of Directors; and with the National Association for Research in Science Teaching, serving as President in 1984-85. Over and over again he has been called upon to counsel publishers of science textbooks, school districts, and state departments of education. The spreading ripples of his influence may perhaps best be glimpsed by the results of his National Science Foundation training grants for science teachers, through which 8,000 participants received rejuvenating instruction, more than 800 earned masters degrees, and over 50 advanced towards their doctoral degrees.

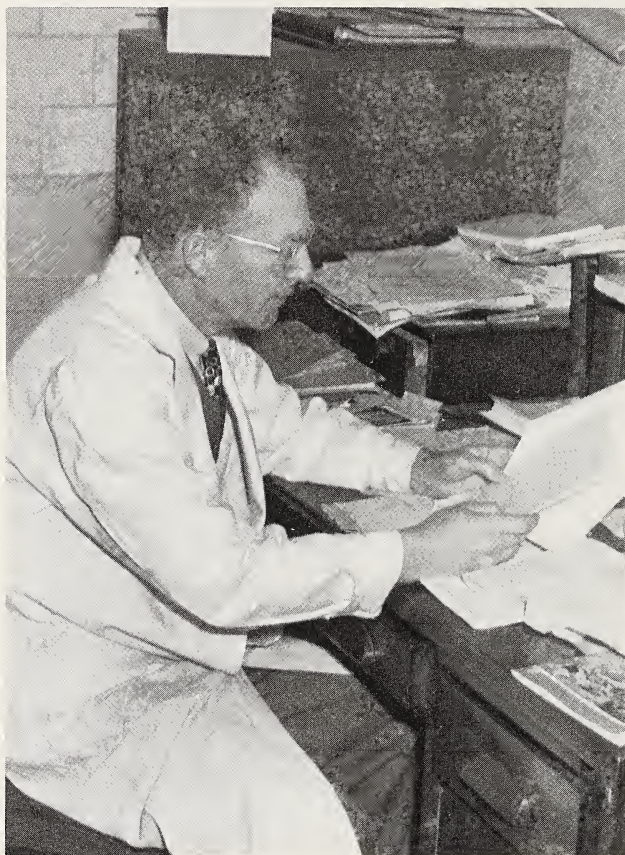
In the field of science education Dr. Thompson has kept abreast of the latest developments, contributing a steady stream of addresses and publications to the work of his professional associations and to ad hoc panels and conferences.

It is perhaps surprising to those who do not know him well that so busy a man could find the time to be a mover and shaker in the Virginia Academy of Science. From the time of his initial appointment as a member of the VAS Advisory Panel on science Education in 1955, Ertle Thompson has almost continually held office of some kind in the Academy. He has served on the Membership Committee, the Virginia Junior Academy Committee, and the Science Advisory Committee, where he was instrumental in preparing the 1982 report on Science, Engineering and Technology Resources in Virginia. It was inevitable that Dr. Thompson should become the President of the Virginia Academy for 1982-83. He has been the Science Advisor to the Governor and has represented him on the National Governors Council on Science and Technology. He has served as the Academy delegate to the AAAS, in which capacity he was elected President of the National Association of Academies of Science, 1985-86 and Chairman of Section Y, General Interest in Science and Engineering 1988-89.

Ertle Thompson has been recognized nationally for his contributions to science education. He has received the National Science Teachers Association Citation for Distinguished Service to Science Education and the Distinguished Service Award of the National Association of Academies of Science. The Virginia Academy of Science honors itself in honoring Ertle Thompson with Ivey F. Lewis Distinguished Service Award for 1989.



## NECROLOGY



**John Campbell Forbes**  
**1922-1989**

Dr. John Campbell Forbes, retired Professor of Biochemistry at the Medical College of Virginia, Virginia Commonwealth University, Richmond, died on May 25, 1989, in Eden, North Carolina of cardiopulmonary failure after a short illness.

Dr. Forbes, the youngest of six children, was born August 26, 1922 in Medford, Cape Breton Island, Nova Scotia, Canada. He received his AB and MA from the University of Saskatchewan in 1920 and 1922 respectively, and his PhD in biochemistry from McGill University in 1925. He served throughout World War I in Princess Patricia's Canadian Light Infantry, was in the battles of the Somme, Cambrai, Ypres and Paschendael, and was seriously wounded in September 1916 and September 1918. He married Irene Byrd Duval in 1926 and had a very happy marriage until her death in 1968. He was most fortunate to marry Mrs. Caroline Price Mori in 1977, with whom he resided until his death.

After a year of fisheries research with the Biological Board of Canada in Halifax, Nova Scotia, he came to the United States and taught chemistry for a year at



Haverford College in Pennsylvania. In 1927 he joined the Department of Biochemistry at the Medical College of Virginia where he remained for 38 years until his retirement in 1965. During most of the 1950's and 1960's, he resided at Rose Hill, Hanover County, Virginia, a beautiful pre-Revolutionary home of considerable historical significance. In 1966, he moved to the Washington, DC area to be near his son and his family. For a period of almost 40 years, he taught every medical, dental and pharmacy student at the College, and maintained an active research program, resulting in over 100 published papers and bringing him national and international recognition. His primary fields of clinical and experimental animal research concerned fractionation of serum lipids, compartmentalization of cholesterol among serum lipoproteins, agents affecting hypercholesterolemia, biochemical and nutritional aspects of alcoholism and clinical chemistry.

He established the clinical laboratories for the College Hospitals in 1927, and supervised clinical chemistry until 1947. He established the first graduate education program at the College in 1934; this has now evolved into the internationally renowned School of Basic Health Sciences. He initiated the weekly Biological Seminar at the college in 1934; he was elected to membership in the American Society for Biochemistry and Molecular Biology in 1937; was chairman of the Virginia section of the American Chemical Society, 1958-1959; President of the Virginia Academy of Science, 1958-1959; received the Distinguished Service Award of the Virginia Section of the American Chemical Society in 1955, and was elected to the first class of Fellows of the Virginia Academy of Science in 1970 and to honorary life membership.

With the title of Professor Emeritus conferred by the Board of Visitors of the College in 1965, he continued his research program for several years with support from the National Institutes of Health. In 1973, the School of Basic Health Sciences established the John C. Forbes Graduate Student Honors Day, which occurs annually, providing recognition of graduate students for excellence in research. The guest lecturer for the event in 1989 was the Honorable Lauro F. Cavazos, Secretary of Education in President Bush's Cabinet. In 1987, the Class of Medicine of 1953 raised sufficient funds to permit the current restoration of the foyer of the Maupin-Maury House, headquarters of the MCV Alumni Association, which, when completed, will be dedicated in honor of Dr. Forbes. His portrait will hang in the foyer in perpetuity, and Dr. Forbes was present for the unveiling in April 1987.

He was a life-time member of the United Church of Canada, and in recent years attended services at the Presbyterian and Pentacostal churches in the Eden, NC area.

Survivors include his wife, Caroline Price Forbes; a son, Dr. Allan L. Forbes and his wife Janie of Rockville, Maryland; a granddaughter, Laurie Forbes Klinedinst of Hattisburg, Mississippi; a granddaughter, Ellen Forbes Hryniewski of Kingston, Ontario, Canada; and a grandson, John Campbell Forbes of Fredricton, New Brunswick, Canada. A memorial service was held May 29, 1989 and interment was June 2 at Parklawn Cemetery, Rockville, Maryland.

The Family requests memorial contributions be provided in support of the John C. Forbes Graduate Student Honors Day, School of Basic Health Sciences, Medical College of Virginia, Virginia Commonwealth University, Richmond, VA 23298.

**VAS Executive Committee Meeting Minutes**

November 6, 1988

University of Virginia (Ruffner Hall)

The meeting was called to order by President S. Ware at 9:42 a.m. Present were M. L. Bass (president elect), C. Blair (treasurer), R. B. Brandt (secretary), R. D. Decker (VJAS), B. M. Bruner (VAS executive secretary) and E. Thompson.

The minutes from the May 27 Council meeting were distributed and noted that the Executive Committee minutes are published in the Fall 1988 Va. Acad. J.

It was noted that Treasurer Blair has taken care of the tax status.

Council must approve two members of trust committee.

The published minutes (prepared by Paul Homsher) of May 25 were discussed.

The status of the VAS directory is that it is completed but not proofread and a photocopy was distributed although some spaces were still blank. The Chairman of the Flora Committee (VACANT). Addresses and some telephone numbers are missing and some non-standard abbreviations were used.

The President-elect should start to select his committees. It was questioned if it should be published in the journal. It should be added to the list of responsibilities that "President-elect should select his executive committee prior to assuming office of the president."

Two members were added to the Finance and Endowment Committee Fund, Don Cottingham and Patricia Fishback.

It was suggested that members of the committee be rotated.

Bruner suggested that the directory should be printed in the reprint issue. Thompson suggested that the Directory Issue be so marked and added to abstract issue (Summer #2 or Fall #3) and be Proceedings and Directory.

Blair asked were sections good about changing officers and cited one that wasn't. Sections should be reminded to hold elections. Discussion on this and on Directory with Decker suggesting that a motion be made to Council that the President-elect include the Directory with the Proceedings issue.

The next issue was the 1990 meeting of the VAS. The Associate Provost of William and Mary has been contacted but not replied. University of Richmond has declined for 1990. George Mason was suggested as possible; however, no member of GM is on the Council suggesting a problem. Bass suggested appoint one to a committee, possibly Membership (Ware). Thompson noted that problems with parking occurred last time at GM although the meeting went well and the President of the University was supportive. Thompson asked about Mary Washington and Bass replied, "not big enough at this time". Thompson pointed out that it is important to get GM involved and that everything is handled by Convention Centers at both VPI and GM. Bruner warned that local arrangement chairman (LAC) must know local conditions to find potential hidden charges. Decker pointed out that before a school was invited the charges must be found. The president or comptroller of a university must sign some contract right away (parking, security, etc.) about the meeting (Thompson).



Bruner called this an "agreement" not contract. We are dealing with \$100,000 meeting. An example of unexpected charges were about \$900 for parking charged to VAS by UVA (Decker). Nothing was given and we were charged for rental. Ware said we knew this in advance (confirmed by others). Difficulty in university giving (Bass) and really universities don't owe us anything but should make the charges clear (Bruner). Pointed out that we about broke even at UVA meeting (Bruner). Some charges have appeared afterwards which may have been at the local arrangements levels (keys, etc.). Ware said we need a "system" for LAC other than President-elect. Decker pointed out that we really need a "Meeting Committee" again. VPI in 1991. Discussion that the details should be worked out. Since the university appoints LAC he frequently doesn't know about the Academy (Decker). It was suggested that two year advance for LAC (Brunner) and that VPI LAC should meet in March and May with the Council. The LAC for VCU is Haas, who has a letter from the university president which is required (Bass). Ware again reminded that 1992 meeting place needed and Bass will contact GM or Mary Washington. Ware will let us know as soon as possible. Brandt said deadline required. Ware will do so and also remind VPI. If no available university is found a convention center could be used. This has been done before (Decker).

Discussion proceeded to the VAS journal. Jim Martin was praised by all for the quality of the journal which looks "typeset". It was suggested that Martin (JM) be given a service award (Bass). Bass at this time left the meeting to suggest this to the Award Committee. Discussion followed on the journal and how articles were now being submitted on computer disc.

Ware brought up the lecturer for the Negus lecture at the VAS meeting and that it is a duty of the president to find one. Winners of the State Science Award (Decker), Carrie Spitzer of NASA and George Simmons, VPI on Antarctica were recommended (Thompson). (Bass returned to the meeting)

Discussion continued on the Negus lecture. Blair suggested an Oceanographer from Woods Hole (Gabe Czady). Ware said he would try NASA. He also asked how much for the speaker and Brunner replied "\$200". Thompson mentioned a problem with loss of the audience when the meeting shift occurred from the banquet hall to the auditorium. Decker also mentioned his need for VJAS speaker (\$300) and thought state people would be appropriate.

Bass reported on his conversation with the awards committee and said that the Executive Committee can give a service award with a letter. Some discussion resulted with the agreement that the Executive Committee will present the award bypassing the Council, and not using the "Distinguished Service" since this was already an award of the Academy. Bruner also suggested that Martin be made a Fellow of the Academy. Discussion resulted including by-law change to increase number of fellows or Emeritus status to some current fellows. The Awards Committee will be notified of suggestions. Ware and Bass will work on the wording of the certificate for JM and Ware will nominate him for Fellow.

The president continued with a communication from Jay Stipes on the Agricultural Sciences Section who suggested that it may dissolve the section due



to poor attendance at papers. Members might shift to Botany or Biology. This was only for information not action.

The president then asked Bass (as president-elect) to report on LAC. Bass said that he was impressed and passed around a draft statement of progress. Brandt asked for a copy to be sent to him for the record and Bass replied in the affirmative. Bass said that he was confident that before January everything would be ready (Meeting May 23-26). Security at VCU was discussed with the comment that maps of controlled areas be supplied. A smaller attendance for the VJAS may result (Thompson), however at least a thousand will attend (Decker). Discussion on the meeting occurred with confidence that there would be no problems on the meeting or the arrangement.

Ware gave a preamble to the Thompson report on the Ad Hoc Committee on Fund Raising and Future for the VJAS. Alternate plans were suggested including 1) regional meetings at community colleges using local volunteers 2) modification of the current operation where the university where the director was provide released time for the director. The overwhelming feeling was that a paid director (combined Executive Secretary and Chairman of the Jr Academy). Fund raising would also be a major function. \$900 was raised in May. In the October 27 meeting of the Committee (Decker, Fishback, Cottingham, Bass). It was suggested that the \$900 will be used for a brochure about the VJAS for fund raising and this will be finalized at the 15 November meeting. A discussion took place about the Fund Raising Committee. An endowment of about \$1,000,000 for \$60,000 cost per year was going to be needed.

Since Decker has agreed to stay on through 1991 the planning time is not as rigid, although if progress isn't made by March some of the alternate plans should be explored. Extend time for report to March 1990. However still may need regional meeting (Decker). This would spread the universities available but have fewer students at state meetings (Ware). This would also allow more interest in the state and allow community college involvement (Thompson). This is a task for the permanent director to look at the regional system. Ware will present to Council about delay in Ad Hoc report. At the next Council meeting we must get regionalization underway (Ware). Ohio has regional meeting (Thompson). Magnet schools present a problem due to their excellent background in competition in science in Virginia.

Report: from Ex Sec. Treas. - Invoices are in the mail for next year (Bruner).

VJAS - Decker - most has been said. At the meeting of State Science Teachers meeting in VA Beach there was support for continuing VJAS. Very positive.

Fund Raising & VJAS future - no report other than meeting was held.

Publicity - no report (Decker was notified by O'Brien).

Bylaws - Update published in the journal.

Also an update should be done on the VJAS.

Meeting was adjourned by President Ware at 12:14.

Submitted

Richard B. Brandt

Secretary, VAS

## VIRGINIA ACADEMY OF SCIENCES COUNCIL MEETING

November 6, 1988

University of Virginia (Ruffner Hall)

The meeting was called to order by President S. Ware at 1:35pm.

Others present were C.R. Taylor, J. Murray, C. Blair, E. Thompson, D. Decker, A. Conway, A. Burke, V.B. Rensburg, D.V. Ulrich, G.R. Taylor, Jr., H.M. Bell, B.M. Bruner, J. Martin, M.K. Roane, M.L. Bass and R.B. Brandt.

The May 27, 1988 minutes were passed out and the printed minutes of May 25, 1988 were approved. Two minor typographical errors were corrected and the minutes were approved.

A rough draft of the directory was passed out by Ware. Ware proposed that the President-elect will in the future select, committee chairman prepare the directory and send this along with the proceedings for the VAS journal. This will be marked as a directory on that journal. This was proposed by Burke and seconded by Conway. This will be included in the duties for the future president-elect.

General discussion was positive including concurrence by the editor of the journal. Unanimous approval.

Need to appoint two members of the Trust Committee. Paul Homsher and Maurice Row. Motion by Burke, seconded by M. Roane. Approval unanimously.

Ware mentioned the computer printing of the VAS journal and its high tech quality and praised J. Martin. Ulrich pointed that Ware was responsible for modernization of the process.

VAS meeting 1990, University of Richmond regrets. William & Mary contacted through Associate Provost. In 1991 at VPI, although they must be reminded of the agreement. Question by Burke, was there a committee for planning meeting? An ongoing committee (Rensburg). Need for the committee (Ware). The By-law committee may be consulted to combine this duty with the nominating committee (Burke). VPI should be consulted since 2 years at least required (Roane). Ware will check with Banks on this VPI meeting.

President-Elect reports on local arrangement committee (LAC). Ware and Bass met with Haas and were very pleased with the arrangements. All systems in place and will meet again with Haas. Rensburg wanted information on the meeting site for the Fellows. Bass said that he will look into this for Thursday morning and send to Rensburg, including costs. Virginia Ellett may take over the Fellows meeting for Rensburg. Murray asked if we had a speaker for VAS meeting. No, but working on it for both Negus and Jr Academy. (Bass). Holiday Inn is the Headquarters hotel (Belvidere and Franklin).

VJAS information - VA Association Science Teachers. VAS had an exhibit and two presentations by Decker. Rensburg asked how the exhibit looked. Good! No update needed (Decker). If needed, please let us know (Rensburg). The exhibit dates back to 1980-81.

AAAS Report - Meeting in SF-everything on pace, except new executive director of AAAS needed (Thompson).



Report on Visiting Scientist Program. Sent to various colleges on 10 September Biggest problem is getting scientists to respond. (Bell).

Finance Committee Report Burke presented on the report of finance committee which was the work of Bruner. This report has to be modified by Burke to show actual expenditures 1988 to date. This will be added as a third column. Ignore figures on an Advance Payment of Dues (This is for inspection only). Burke described the budget in some detail. No principal changes. Interest (return) and investment income is up. Academy may be faced with higher travel funds, since E. Thompson as a delegate for AAAS gets funds from the national AAAS. In the future this will change. The \$4000 increase shown in the proceedings of the VJAS is due to publication of two years of proceedings and increased size. Bell asked, if this does any good? Decker said that the distribution was to the school and the students who have abstracts about 135-140 schools. Burke suggested that VJAS should look into this. Still one year behind. Discussion continued on the abstracts being behind. Thompson pointed out that the abstracts are valuable in working with student-teachers. Requests are always coming in for abstracts from other academies and students for their presentations. Murray suggested that only the large prize winners should be published and not all (32 first prize). This will be part of discussion for VJAS committee. Burke reported on the continuing problem of the Bethel H.S. Fund. The committee recommends that this be resolved and that the president appoint a committee to examine this fund. Expenditures of \$1000 with receipts less than \$500 mean that this underfinanced Fund will eventually be spent out. Burke discussed this at length pointing out difficulties.

1. President to appoint Ad Hoc Committee (Decker should be on this) to look into Bethel Fund and speak to Bethel group.
2. Amend budget to be \$500 this year both in and expended.
3. Finance Committee wants a one time \$1000 transfer from general fund into the principal of the Bethel Fund.

This was separated into three motions. Burke proposed the first motion and it was seconded (Roane) Decker presented some history of the Bethel Fund where \$10,000 was to be raised to give two \$500 scholarship/year for students for VJAS. Gave \$4700 first year. With interest the total fund grew to \$8900. They anticipated that this would both generate \$10,000 and allow the awards (1000) and a \$50 fee (administrative to the academy). However, growth of the funds did not cover expenditure. Stipulation was that base funds can not be touched. Discussion on the first proposal, that Ulrich and Decker should be on the committee. Remsburg pointed out that the award last year was using the principal. Ulrich asked where the original agreement was? and pointed out that the academy shouldn't agree to granting \$1000 and never touching principal. They have the right to withdraw funds (Remsburg). Why doesn't this problem belong to the VJAS. (Ware) because we have already funded this. Decker - funds in the hands of trust committee.

Motion unanimously approved. Part 2. Resolution \$500 in - \$500 out. Decker thought that the original agreement was October in 1984 or 1985. The Archives Chairman will check this (Ware). A unclear motion was made (Burke),



rephrased, and rephrased again. The secretary asked that this be presented in writing, however Burke restated it. "The amended proposal that Finance recommends is that the proposed budget for the year 1989 show \$500 instead of \$1000." Murray asked did the agreement pass Council (The Bethel Agreement). During G. Bass presidency (Thompson), but unknown if approved. Council may not have approved (Decker). By giving to the Trust Committee, Council accepted (Burke). It should be in minutes of JMU meeting. Discussion continued with some confusion. Was money spent from the principal and if so, how much (Brandt)? Ulrich says principal approximately \$8400 and started with \$8900. Thompson summarized the problem to the Trust Committee - how much contributed, how much earned, how much spent (three awards). This gives the answer to how much is present. Bethel can they be contacted with the options available for the fund. Motion - \$500 for receipt \$1000 for dispersement." (apparently seconded earlier Blair?) 13 in favor 3 against.

Burke on the third proposal - (as modified by Ulrich) "Add \$1000 to Bethel Fund from general fund if deemed wise after discussion of the budget committee with Bethel." Discussion dwelled again on original principal (ie \$8900). Bethel must understand that the principal can not be guaranteed against expenditures based on an income that varies (Ulrich). Motion approved unanimously.

Burke reported a recommendation from Finance for future consideration that each section has a draw of \$100 plus \$1/member (first membership section). Council shall not prescribe its use. This is not a motion but should be considered at the next council meeting (15 sections + \$1100 for a total of \$2600). Discussion of this was based on previous similar past motions. It was pointed out that we can get money by submitting a bill. The president already has \$1000 to do this (Bruner). Thompson said he thought it was already approved however, Murray pointed out this was different in that it would not required for the president to approve. Ware said that he would have the Burke suggestion considered at the next council meeting. Decker asked if we find what we have so that it can be compared to the present discussion. The Archivist (Roane) was asked to retrieve the minutes (1986). It may have been disapproved (Bruner). Burke asked that all motions be prepared and logged and the long range planning committee could monitor. Ware-"between now and the next meeting the previous decisions on these funds will be investigated. Finance Committee report accepted."

Reports from Committees (Ware). In the Executive Committee discussion took place about on the Fund Raising Committee, which was to report on raising funds for a permanent director by March. Decker has been convinced to remain one more year, which removes some pressure. The deadline for the report can be extended from March 89 to March 90. Recommend to council that final decision at the outside will be March 90. Approved.

Committee on Museums (Murray). More time needed and will report at the next council meeting.

Committee on Evolution (Remsburg) Still standing.

Publicity (Ware for O'Brien) VCU has publicity office, but we will attempt to expand on this.

Business - no report

Archives (Roane) - Request that everyone turn in materials so they can be stored in proper place.

Awards (Taylor) - Recommendation will be made in March meeting.

Constitution & Bylaws. (Chairman not present but delivered by Decker). Revisions published in the VAS journal, but the VJAS still needs revision.

Science Education (Thompson) Excellent response at VA Beach meeting. Over 700 in attendance. Thanks to Ellet and Burke for service (Ware and Remsburg) Discussion by Burke on how funds were spent on exhibit.

Fund Raising Committee (Taylor) Written report. Progress will be presented at upcoming meetings.

Membership committee - No Report. Ware says that two vacancies to be filled by geographical representation.

Nominations & Election - No Report.

Publication (Jim Martin). The journal is on schedule. Engineering abstracts were not submitted on time and were not included. Sixty papers have been submitted. The next open slot for publication is September. The journal is growing in size. Cost is down, but since larger issue, more expensive. Reprint cost cut in half. All papers submitted in both type script and IBM compatible, MSDOS 5 1/4". The next issue will be in the first week in January. Turn around time about three months for manuscripts. Three symposium are in progress for publication. Since journal is growing we should not discourage publication (Decker) by limiting the size. Advanced sales are also occurring. Research Committee - No Report

Science Advisory Committee - No Report

Trust Fund Committee (Ulrich). At the last Council meeting the Trust Committee was asked to enhanced the research committee funds from \$4500 to \$6000. Funds were transferred in investment to a Bond Fund paying better than 11%. The lumping together of the Fellows fund (\$2400) with others including the General Fund 0(\$40,000) have done. To simplify the process these many funds will be separated into separate accounts (combined Botany VAS, VJAS and Jones Fund). These small fundstotal about \$1100 and will be combined. In a meeting with Paul Honsher and Paula Colyer on July 12 and this plan agreed on. A new account was to be opened for Bethel, but based on todays discussion, this will be deferred. Comments were made on investment cost. (Ulrich). Burke mentioned some problems with costs of investment decreasing principal of some funds that we agreed would not decrease in principal. This should be followed up at spring council meeting to see if this been happened. Do we need a resolution (Ware)? Burke said we may after the spring reports are presented. Murray had a question. The original intent of council was to set up one large fund in order to get maximal amount of return on the capital with the various small funds to share proportionally. Is that just impossible, from the point of view of accounting? Ulrich-this is not impossible, but Colyers would challenge the assumption that we would get more return from a larger fund and by moving into separate accounts this would simplify the process. Brandt said, we had a very lengthy meeting where the decision to simplify by combining all the small



fund was decided. Each fund would have a proportional share. Discussion continued, with Ulrich saying it would be simplified, using Colyers as an expert opinion. Ware supported this. Brandt and Remsburg were not convinced, however Ulrich assured Council that it would be clear in the spring meeting. Burke moved that the council reaffirm its faith and appreciation in the Trust Committee. Seconded by Decker. Discussion followed where Ulrich pointed out that the difficulty was compounded by having to invest these funds, reviewing the problems involved. Burke supported the committee. The vote was unanimous for approval.

Virginia Flora Committee - No report, since there is at this time no chairman (although still functioning).

OLD BUSINESS - NONE

NEW BUSINESS - Decker said that the discussion at the Executive Committee dealt with the duties of the President-elect. It is more logical for the Past-President to run the annual meeting allowing for more experience. Discussion was positive. Meeting adjourned at 4:20 by S. Ware.

Submitted by Richard B. Brandt

Secretary, Virginia Academy of Science





COLLEGE OF AGRICULTURE AND LIFE SCIENCES

## VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

HAMPTON ROADS AGRICULTURAL EXPERIMENT STATION

1444 Diamond Springs Road  
Virginia Beach, Virginia 23455  
(804) 446-4900

May 24, 1989

Dr. James H. Martin  
Dept. of Biology-PRC  
J. Sargent Reynolds Community College  
Box 12084  
Richmond, VA 23241

Dear Dr. Martin:

As I discussed with you, we had an unusually low turnout for the Agricultural Science Section of the Virginia Academy of Science meeting. Only ten titles were submitted. After the program was printed, six of the ten papers were cancelled due to the low turnout. The remaining four authors were still interested in presenting their papers but felt it was not worthwhile to present a talk to a group of three people.

Due to the short time involved, and the program having already been printed, the Agricultural Science talks could not be moved to another section. Although the journal has a policy of not printing an abstract if the talk was not given, I submit that the cancelling of an entire section is an unusual circumstance and request that the abstracts be printed. Since the intended participants in the section prepared an abstract and probably had their slides and talk prepared (as I did), then perhaps the publishing of the abstract could be justified.

I have enclosed the ten abstracts submitted to me. I appreciate your consideration of this matter.

Sincerely,

Jeffrey F. Derr  
Ag. Science Section Secretary

cc. Dr. M. D. Lindemann  
Dr. G. W. Zehnder  
Mr. M. A. Coffelt  
Dr. L. I. Miller  
Dr. E. T. Kornegay

COMPARISON OF OVALBUMIN, TWO LEVELS OF LYSOZYME AND SHEEP RED BLOOD CELLS AS ANTIGENS FOR WEANLING PIGS WHEN INJECTED I.M. WITH AND WITHOUT MALDROX. E. D. Bonnette\*, M.D. Lindemann, K.L. Barnett, C.R. Risley, H. Swinkels & E.T. Kornegay, Va. Polytechnic Inst. & State Univ. Blacksburg, Va. 24061. Two trials were conducted with crossbred weanling pigs (n=96) to compare the immune response to ovalbumin (3 mg), two levels of lysozyme (100 and 20  $\mu$ g) and sheep red blood cells (10 $\mu$ l, packed and washed). Each antigen was injected in 1) 100  $\mu$ l maldrox (mixture of ALOH and MgOH), 100  $\mu$ l Freund's complete adjuvant and 800  $\mu$ l of sterile saline or 2) 100  $\mu$ l Freund's complete adjuvant and 900  $\mu$ l saline. Pigs were injected i.m. d 1 and 17. An enzyme-linked immunosorbant assay was used to measure the response to ovalbumin and lysozyme, and a hemagglutination assay was used for sheep red blood cells (RBC). ADG was monitored and found to be similar for all treatments. The use of maldrox did not consistently improve the immune response ( $P=.06$ ). The secondary response to ovalbumin was about 2 dilutions ( $P<.01$ ) greater than for lysozyme, and 7.2 dilutions ( $P<.01$ ) greater than sheep RBC. The improvement in response to the higher level of lysozyme was not significant ( $P>.10$ ). In summary, both ovalbumin and lysozyme (at both levels) produced a stronger primary and secondary response than sheep RBC with the magnitude of the response greater for the primary response.

JUSTIFICATION OF AN URBAN INTEGRATED PEST MANAGEMENT PROGRAM FOR THE ORANGE-STRIPED OAKWORM. M. A. Coffelt and P. B. Schultz, Dept. of Entomology, Va. Polytech. Inst. and State Univ., Hampton Roads Ag. Exp. Stn., Virginia Beach, Va. 23455. Orange-striped oakworm, *Anisota senatoria* (J. E. Smith), defoliation of city of Norfolk pin and willow oaks has significantly increased since 1981. Justification for an integrated pest management program for oakworm was based on the high monetary value of urban oak trees, and the large pesticide volume sprayed for oakworm control. From 1981 to 1987, insecticide cover sprays were applied by city employees at citizen request to control oakworm, which produced needless insecticide application. Over 50% of citizen requests for pesticide application in 1987-1988 were for trees with less than 5% defoliation. Monitoring and establishing an aesthetic threshold of 25% damage in 1988 resulted in a decrease in pesticide volume of 80% and a savings of \$3,500 over the previous year, with minimal defoliation. Future IPM strategies for this pest will emphasize monitoring, biological control, biorational pesticides, and judicious pesticide application.

TRICLOPYR FOR PERENNIAL BROADLEAF WEED CONTROL IN APPLES AND PEACHES. Jeffrey F. Derr, VPI & SU, Hampton Roads Ag. Exp. Sta., Virginia Beach, VA 23455. Triclopyr at 0.25 and 0.38 lb/A provided good to excellent control of Virginia creeper (90-97% control) and poison ivy (77 to 87% control) two months after treatment. Combinations of triclopyr at 0.31 and 0.5 lb/A with 2,4-D at 0.6 or 1.0 lb/A or with glyphosate at 0.5 lb/A resulted in excellent (90% or greater) control of both species. Application of triclopyr to a single apple or peach branch injured or killed the treated branch but did not cause injury to the rest of the newly planted tree. No tree injury was observed with triclopyr applications to 6 inches of bark of apples or peaches. Glyphosate caused severe injury to apple and killed peaches following treatment to one branch. Glyphosate severely injured peach but did not injure apple following bark exposure.



OVULATION RATE AND FETAL SURVIVAL AND DEVELOPMENT AT DAY 45 OF GESTATION IN GILTS FED DIETS SUPPLEMENTED WITH FOLIC ACID. A. F. Harper, M. D. Lindemann & E. T. Kornegay, Dept. of Animal Science, Va. Polytechnic Inst., Blacksburg, VA 24061. Sixteen gilts were slaughtered to assess the effects of supplementing the diet with folic acid on reproductive performance. Treatments consisted of a diet with 0 or 2 ppm supplemental folic acid. Diets were fed at a rate of 1.8 kg/hd/d throughout the experiment starting at least 21 d prior to breeding. Gilts were slaughtered at d 45+2 of gestation; the reproductive tracts were removed and each fetus and placenta were separated. The following variables were measured: placental length and weight, fetal crown-rump length and weight and allantoic and amniotic fluid volumes; empty uterine weight and corpora lutea number on each ovary were also determined. Number of live fetuses and fetal survival percentage favored folic acid supplementation by .25 fetuses and 4.25% respectively, but these differences were not significant ( $P>.10$ ). While mean fetal number and fetal survival percentage responses were in the anticipated directions, the dietary supplementation of 2 ppm folic acid did not significantly affect ovulation rate, fetal development, or fetal survival at day 45 of gestation in swine bred for their first parity. Further work with third parity females is progressing.

EVALUATION OF ASPIRIN IN WEANER DIETS WITH AND WITHOUT SOYBEAN OIL. E. T. Kornegay, Zi-rong Xu\*, L. A. Sweet, M. D. Lindemann, H. P. Veit\* & B. A. Watkins. Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061. Crossbred pigs ( $n=108$ ) weaned at 4 wk of age (8.1 kg) were used to examine the effectiveness of aspirin (125 and 250 ppm) in combination with 5% soybean oil for improving performance and reducing scours. Improvements in average daily gain and daily feed intake were observed, primarily in the latter half of a 6-week trial, when both 125 and 250 ppm aspirin were added to a starter diet without soybean oil, but the addition of aspirin had little effect in a diet with 5% soybean oil. Efficiency of feed utilization was not affected by aspirin. As reported previously, aspirin was effective in reducing scouring of weanling pigs and caused no detrimental effects as evaluated by selected blood measurements and gross necropsy examination of slaughtered pigs. The addition of 5% soybean oil did not affect performance, but elevated the levels of omega-3 (18:3w3) fatty acids in both plasma and liver lipids; the magnitude of the increase in plasma was larger when the diet also contained aspirin.

MORPHOLOGICAL COMPARISONS OF SECOND-STAGE JUVENILES AND MALES OF ONE ISOLATE EACH OF HETERODERA GLYCINES, H. CRUCIFERAE AND ONE OF THEIR HYBRIDS. L. I. Miller, Dept. of Plant Path., and Weed Sci., VPI&SU, Blacksburg, VA 24061. Comparisons were made of 21 second-stage juveniles and 21 males of one isolate of *Heterodera glycines* (N) cultured on 'Lee' soybean, of one isolate of *H. cruciferae* (C) cultured on 'Market Prize' cabbage and of one of their hybrids (NC) cultured on 'Kobe' lespedeza. Dimensions in  $\mu$ m were as follows—(JUVENILES) base of stylet knobs to dorsal gland orifice: N 3.0-4.4 (mean 3.8, standard deviation  $\pm 0.4$ ), C 6.0-7.5 ( $6.7 \pm 0.4$ ), NC 4.7-6.2 ( $5.4 \pm 0.4$ ); center of median bulb to ventral pore: N 24-37 ( $30 \pm 3.8$ ), C 20-35 ( $31.9 \pm 1.8$ ), NC 37-44 ( $30.8 \pm 2.0$ ); head tip to center of median bulb: N 66-76 ( $71.0 \pm 3.4$ ), C 63-73 ( $68.7 \pm 2.7$ ), NC 55-70 ( $63.6 \pm 4.5$ ). (MALES)—stylet length: N 25-28 ( $27.1 \pm 0.7$ ), C 25-30 ( $27.2 \pm 1.3$ ), NC 24-28 ( $26.2 \pm 1.2$ ); head tip to base of esophageal glands: N 175-219 ( $188.7 \pm 9.6$ ), C (162-215) ( $188.1 \pm 17.9$ ), NC 186-218 ( $198.3 \pm 9.1$ ). All characters of juveniles were significantly different ( $P=0.05$ ) for N, C and NC. The two characters of males for N and C were not significantly different; however dimensions for the NC hybrid differed significantly from the N and C parents. The NC hybrid was able to reproduce on soybean, cabbage and 'US75' sugarbeet.



THE EFFECT OF FEEDING DIETS CONTAINING CITRIC AND FUMARIC ACIDS ON THE FEEDLOT PERFORMANCE, AND ON THE INTESTINAL pH, CHLORIDE ION AND VFA CONCENTRATION OF EARLY WEANED PIGS. C.R. Risle<sup>1</sup>, E.T. Kornegay<sup>1</sup>, W.E.C. Moore<sup>2\*</sup>, M.D. Lindemann<sup>1</sup>, C.M. Wood<sup>1</sup> and S. Weakland<sup>1\*</sup>, <sup>1</sup>Dept. of Anim. Sci. and <sup>2</sup>Anaerobic Microbiol. Va Polytechnic Inst. and State Univ., Blacksburg, VA 24061. The effects of adding 1.5% citric acid (CA) or fumaric acid (FA) to an 18% CP starter diet (control) on the ADG, avg feed intake (ADF), and feed to gain ratio (F:G) and on the pH, chloride ion (Cl<sup>-</sup>) and VFA concentration in the stomach, jejunum, cecum and lower colon were evaluated with 144 pigs weaned at 28 d of age. ADG and ADF were not affected by dietary treatments; however, CA improved (P<.07) F:G compared with the control. The effects of feeding FA and CA were more evident during the first 4 wk of the trial; improvement in F:G were observed for FA (P<.07) and for CA (P<.04). ADG was only improved (P<.05) for CA during the first 4 wk. Intestinal parameters were evaluated at the conclusion of the trials from 27 pigs. No dietary effects of FA or CA (P>.3) were observed for pH or Cl<sup>-</sup>. FA increased the concentration of fumarate and hence, total VFA in the stomach (P<.001) and jejunum (P<.02) compared to control and CA diets. No other effects of FA or CA on VFA were observed. In summary, CA and FA had few effects on intestinal parameters measured, but improved ADG and F:G.

THE EFFECTS OF DIETARY AMMONIUM PROPIONATE (AP) FED WITH AND WITHOUT CARBADOX ON GROWTH, SCOURING AND GASTROINTESTINAL CHARACTERISTICS OF WEANLING PIGS. L.A. Sweet\*, E. T. Kornegay and M. Servideo. Virginia Polytechnic Inst. & State Univ., Blacksburg, 24061. Crossbred pigs (n=116), weaned at 28 d of age were used to investigate main and additive effects of feeding 0%, .15% and 1.8% AP with and without 27.5 ppm carbadox on ADG, average daily feed (ADF), feed efficiency (F/G) and the incidence and severity of scours. Intestinal content samples were obtained from 44 pigs (8 at weaning, 12 at d 10 on test, and 24 at d 35 on test) from the stomach, jejunum, cecum and lower colon to determine the pH, and concentration of chloride ion (Cl<sup>-</sup>) and lactic acid. The addition of carbadox improved (P < .05) ADG and increased (P<.10) ADF with no effect on F/G. The main effect of AP was not significant for ADG, ADF or F/G, but an AP by carbadox interaction was observed for ADG (P< .10) and F/G (P < .05). In the presence of carbadox, .15% AP improved ADG and decreased F/G; whereas, the opposite effect was observed in the diets without carbadox. Scouring scores were not influenced by AP or carbadox. Dietary treatments generally had no significant effect on pH or the concentration of lactate and Cl<sup>-</sup> of contents of the gastrointestinal tract.

FETAL AND MATERNAL PARTITIONING OF ENERGY AND NITROGEN RETENTION IN SOWS DURING THE SECOND HALF OF GESTATION. J.W.G.M. Swinkels, J.G.H.M. Heusschen\*, M.W.A. Verstegen\*, W. van der Hel\* and A.M. Henken\*. 6709 PG Wageningen. The Netherlands. The effect of two ambient temperatures (18°C-Th and 13°C-Tl) during d 77 through 112 of gestation (five 7-d balance periods) on energy and nitrogen retention were studied in sows. Eight 2<sup>nd</sup> parity Dutch Landrace sows, fed 1.1 X maintenance (420 kJ kg<sup>-1</sup> d<sup>-1</sup>), were housed individually in balance cages in two respiration units. Heat production was determined (indirect calorimetry). Fetal energy and nitrogen retention were determined using regression equations estimated by Noblet et al. (Br. J. Nutr., 53:251, 1985). Heat production was increased (P<.01), and thus energy retention was decreased (P<.01), for Tl (564 and -60 kJ kg<sup>-1</sup> d<sup>-1</sup>) compared with Th (475 and 32 kJ kg<sup>-1</sup> d<sup>-1</sup>). Total protein (N X 6.25) retention was increased (P<.05) in Th (95 g d<sup>-1</sup>) compared with Tl (69 g d<sup>-1</sup>). Predicted fetal and mammary tissue energy and protein retention were, respectively 25 and 11 kJ kg<sup>-1</sup> d<sup>-1</sup>, and 44.9 and 11.4 g d<sup>-1</sup>, for Th and Tl. Maternal energy, protein and fat retention were, respectively -5 kJ kg<sup>-1</sup> d<sup>-1</sup>, 37.4 g d<sup>-1</sup> and -29.4 g d<sup>-1</sup>, for Th, and respectively -96 kJ kg<sup>-1</sup> d<sup>-1</sup>, 14.3 g d<sup>-1</sup> and -143.8 g d<sup>-1</sup>, for Tl. In summary, sows in Th and Tl mobilized maternal fat for fetal development and maternal protein synthesis.

Incidence of Corn Earworm and Associated Parasitoids in Virginia Soybean Fields. Geoffrey W. Zehnder, VPI & SU, Eastern Shore Agric. Exp. Stn., Painter, VA 23420. The predominant larval parasite associated with corn earworm in 20 soybean fields sampled in the Northern Neck and Eastern Shore regions of Virginia in 1987 and 1988 was Microplitis croceipes (Cresson). High rates of parasitism occurred if M. croceipes was present to coincide with early development of host larvae. Parasitism by M. croceipes occurred even when corn earworm larval density was low. High levels of corn earworm egg parasitism by trichogrammatidae occurred in Northern Neck fields, but not on the Eastern Shore.

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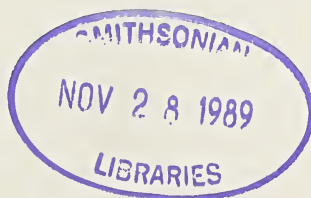
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## Who's Teaching About AIDS in Virginia Colleges?\*

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### ABSTRACT

Two-hundred-fifty-nine full-time ranked faculty at eight Virginia colleges responded to a survey about AIDS-related instruction. Sixteen percent planned for the topic in one or more courses. Additionally, 17% had AIDS topics raised in courses by students. While social service/nursing preprofessional program faculty have responded to the need for information about the epidemic, basic social and natural science faculty have not become a primary source of information about AIDS. Limitations in faculty ability to deal with students' concerns are noted.

### Who's Teaching About AIDS in Virginia Colleges?

In the Fall issue of this journal, Petricciani (1988) summarized the U.S. Public Health Service's view of the short term for the Acquired Immune Deficiency Syndrome (AIDS) pandemic. He indicated once again that education is the only tool presently available to prevent the spread of the Human Immunodeficiency Virus (HIV) beyond the conservative estimate of 1,000,000 persons in this country currently infected. If education is our only weapon, it is important to assess its precision. Recent research has indicated that college students have alarmingly low levels of accurate information about AIDS and have not significantly changed their sexual behavior (Gottlieb, Vacalis, Palmer & Conlon, 1988; McDermott, Hawkins, Moore, & Cittadino, 1987). The present paper reports a survey of the extent to which AIDS has entered its way into the curricula on Virginia College campuses, both formally and informally, and the level of sophistication of that instruction.

### METHOD

**Subjects:** The subjects were 259 professors on eight Virginia college campuses who completed a questionnaire. All full-time, ranked faculty ( $N = 508$ ) on these campuses (three private colleges, one 4-year public institution, one public comprehensive college, and three community colleges) were surveyed with a short questionnaire. Additionally, 40 respondents in whose classes AIDS were discussed completed a follow-up survey.

**Procedure:** Subjects were asked to identify their main disciplinary affiliation and then to include information concerning 1) whether the topic of AIDS was included as part of the planned curriculum in any course during the 1987-1988 school year, 2) whether the topic of AIDS had arisen as part of class discussions

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\* The research reported in this paper was supported by a grant from the Virginia Healthcare Foundation

during that time, 3) in which courses had events taken place, and 4) had they had any formal training on the topic of AIDS. A sample of 20 professors who included AIDS in their curricula and 20 professors who indicated only that AIDS was discussed informally in their classes were sent a follow-up questionnaire which included a 6-item AIDS knowledge test. The questions on this test were in a 6-response multiple choice format and are included in Table 1.

### RESULTS

Forty-two professors indicated that they included AIDS as part of the curriculum in one or more courses (16%). Of the 25 disciplines, 11 included professors who brought AIDS into the curriculum in one or more courses, including, in order, nursing (79%), social work (40%), physical education/health (40%), education (38%), business (31%), sociology (23%), biology (17%), English (15%), chemistry (10%), history (7%), and psychology (6%). The five courses in which AIDS was a topic at two or more schools were human sexuality, nursing practice, social work practice, family life education, and business ethics. Of these 42 professors, 20 (48%) indicated that their knowledge of AIDS was limited to "casual reading" while only 11 (26%) indicated that they had "formal training" including graduate courses in immunology or epidemiology or professional continuing education training in AIDS, and 11 (26%) indicated "systematic reading" as their source of AIDS information.

Forty-four (17%) professors indicated that the topic of AIDS was raised in their courses by students. Nine disciplines were represented, including theater (67%), psychology (44%), sociology (41%), biology (37%), ROTC (29%), political science (25%), history (21%), religion (20%), and economics (17%). In this group, 18 individuals (41%) indicated "no background in AIDS," 13 (30%) indicated "casual reading," 4 (9%) indicated "systematic reading," and 9 (20%) had "formal training" on the topic. The courses in which the topic arose were most often introductory courses in these disciplines.

In the follow-up samples, the average number of correct answers to the information tests was 81.7% for the group that planned AIDS instruction and 75.4% for the group in which the topic of AIDS had arisen without plans. In the group that planned AIDS instruction, 35% indicated that questions were raised that were beyond their background, and in the group that had AIDS raised outside of their curricular plans, 60% indicated questions were raised that were beyond their background.

### DISCUSSION

The finding that 16% of the instructors responding to the survey include the topic of AIDS in part of their curricula can be viewed either positively or negatively. Certainly the extent of coverage in the preprofessional curricula in nursing, social work, and education is encouraging. Virtually all of these instructors indicate some sort of "formal training," and their scores on the information test were high (92%). That another 17% of faculty had the topic raised in courses in which there were no plans for discussion of it, particularly in introductory courses in the natural and social sciences, can be seen as an expressed need on the part of students which presently is not being met by the planned curricula of science instructors. It is certainly discouraging to note the number of faculty in disciplines far removed from



TABLE 1. AIDS Information Test.

- 
1. AIDS in the United States is more likely to be transmitted from men to women than from women to men because:
    - a. homosexual men are biologically more likely to develop AIDS than heterosexuals or gay women
    - b. women are more likely to have healthy immune systems
    - c. heterosexual contact is more likely to result in physical trauma to women than men
    - d. prostitutes frequently are IV drug users
    - e. women are immune to AIDS, in general, and are so less likely to have the virus in the first place
    - f. men have more sexual contacts than women
  2. The major cause of death among U.S. AIDS patients is:
    - a. pneumonia
    - b. a form of cancer
    - c. wasting disease
    - d. kidney failure
    - e. suicide
    - f. heart attack
  3. The best protection against AIDS for sexually active persons is:
    - a. natural condoms with spermicide and no petroleum lubricants
    - b. natural condoms without spermicide or lubricants
    - c. natural condoms with petroleum lubricants
    - d. latex condoms with petroleum lubricants
    - e. latex condoms with spermicide and no petroleum lubricants
    - f. latex condoms without spermicide or lubricants
  4. The percentage of persons who are positive for the HIV-antibody test who will eventually develop frank AIDS is now estimated at:
    - a. <5%
    - b. 35%
    - c. 45%
    - d. 50%
    - e. 60%
    - f. 90+%
  5. Risk of AIDS can be reduced most by
    - a. reducing the number of sex partners
    - b. stopping smoking, increasing exercise, and eating a healthful diet
    - c. eliminating oral sex
    - d. abstaining from sex
    - e. eliminating anal sex
    - f. stopping using drugs, including alcohol
  6. AIDS is known to be transmitted by:
    - a. kissing
    - b. hugging
    - c. sneezing
    - d. vomiting
    - e. tears
    - f. none of the above

the medical and social sciences who are being asked for AIDS-related information. While it might be comforting to believe that religion, ROTC, and theater faculty are being asked questions appropriate for those disciplines, in the follow-up questionnaires, the most frequently listed questions asked by students related to transmission risk, symptoms, and sexual practices.

Many comments on the questionnaires indicated that instructors believe that the burden of teaching about AIDS rests elsewhere, particularly with health

services and residence life programs. The quality and frequency of these programs is highly variable on Virginia campuses, and, until such time as secondary schools have committed to thorough AIDS education efforts, we might not want to stake the lives of our students on such programs. Moreover, our research (Trice & Price-Greathouse, 1987) indicates that those who attend the typically voluntary programs run by these college agencies already have well developed personal concepts about health and high levels of information about AIDS. At the very least, introductory science instructors might consider encouraging students to attend these programs through course bonuses.

This survey has several limitations. Although the campuses surveyed were included for geographic, single-sex vs co-ed, public vs private, church-related vs nonsectarian, urban vs rural, and racial mixes, they may not represent a particular college. Because of financial limitations and difficulties in determining who actually teaches the majority of undergraduates (e.g., graduate instructors and adjuncts), the 6 doctorate-granting public universities in the state were not included. As a biased estimate of undergraduate instruction in the state, this survey suggests that we have begun to educate our students about the medical, psychosocial, and professional issues relating to the AIDS epidemic, but much more effort is needed, particularly among science faculty.

#### REFERENCES

- Gottlieb, N.H., Vacalis, T.D., Palmer, D.R., & Conlon, R.T. 1988. AIDS-related Knowledge, Attitudes, Behaviors and Intentions Among Texas College Students. *Health Education Research* 3:67-73.
- McDermott, R.J., Hawkins, M.J., Moore, J.R., & Cittadino, S.K. 1987. AIDS Awareness and Information Sources Among Selected University Students. *Journal of American College Health* 31:222-226.
- Pettricciani, J.C. 1988. The AIDS Epidemic in 1988. *Virginia Journal of Science* 39:203-212.
- Trice, A.D., & Price-Greathouse, J. 1987. Locus of Control and AIDS Information-seeking in College Women. *Psychological Reports* 60:665-666.

## A Simple and Efficient Method for Isolation of Plasmid DNA From Bacterial Cells Embedded in Agarose

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### ABSTRACT

A method for extraction of plasmid DNA from bacterial cells embedded in agarose has been developed. Embedded bacterial cells are treated with acetone, lysozyme, lauryl sulfate, RNase, and proteinase and then the treated agarose blocks are inserted into the wells of an agarose gel. Upon electrophoresis the plasmid migrates out of the embedding block and into the gel leaving intact chromosomal DNA in the well. This method has been tested with *Escherichia coli* and *Bacillus subtilis* and was found to be effective for plasmid isolation. In comparison to "traditional" methods for small scale plasmid isolation, this new method is less tedious, since chemical separation of plasmids is not required prior to electrophoresis. In addition, a higher yield of plasmid DNA is achieved due to the elimination of fractionation and precipitation steps involved in other methods.

### INTRODUCTION

Isolation and characterization of plasmids from bacteria are necessary steps in many genetic, physiological and ecological studies in microbiology. While current methods are workable and generally effective (Heath *et al.*, 1986; Kado and Lui, 1981), they involve rather tedious extraction and precipitation of plasmids which requires the use of toxic solvents. During chemical extraction of the plasmid, there is loss of plasmid due to the inherent inefficiency of the extraction methods. In addition, with each manipulation, the DNA may be nicked or broken. This is an especially important consideration for large plasmids (Brick-Miller, 1986). This paper describes an alternative method for plasmid separation which circumvents the problems mentioned above.

Most DNA separation methods which are currently in widespread use are a variation on a theme which involves lysis of cells in suspension and subsequent phenol/chloroform extraction and ethanol precipitation of nucleic acids which are subsequently separated by electrophoresis (Heath *et al.*, 1986; Kado and Lui, 1981; Maniatis *et al.*, 1982). As an alternative, some methods for DNA separation have employed agarose embedded cells. Schwartz and Cantor (1984) isolated large (up to 2,000 kB) DNA from embedded yeast cells using pulse field electrophoresis. Brick-Miller (1986) isolated mitochondrial DNA from Erlich ascites tumor cells embedded in agarose blocks. This paper describes the use of a similar approach to isolate plasmid DNA from bacteria.

### MATERIALS AND METHODS

The method which was developed involved embedding bacterial cells in agarose blocks. The immobilized cells were then treated with acetone, lysozyme, lauryl



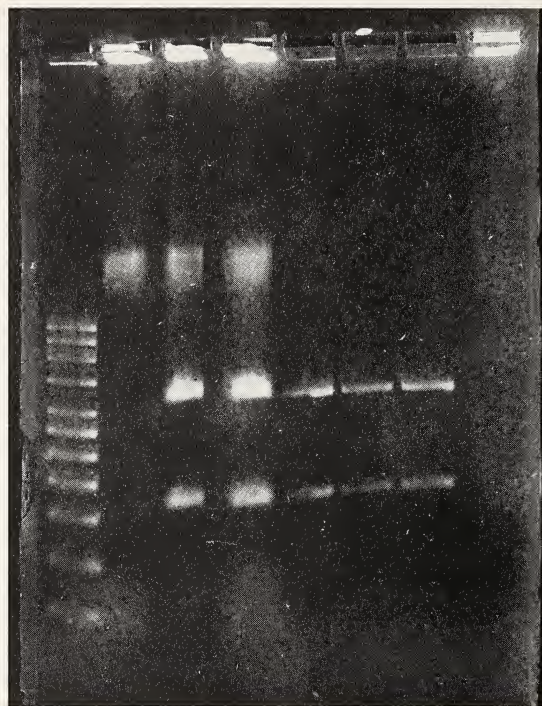


FIGURE 1. Plasmids separated from *E. coli* DH5a cells. Lanes (from left to right): 1, supercoiled standards; 2, agarose embedded, plasmid-free cells; 3-4, agarose embedded cells transformed with pBR322 plasmid; 5-7, pBR322 isolated from transformed cells using the alkaline lysis method; 8, agarose embedded cells that were not treated with lysis reagents.

sulfate (SDS), RNase, and proteinase to degrade the cell wall. Plasmids were separated from cell debris and chromosomal DNA during electrophoresis. To test the method, the following experiment was performed with *E. coli*. Plasmid-free cells were transformed with pBR322 plasmid and preparations were made of both cells containing the plasmid and plasmid-free cells. Plasmid-free cells (DH5a competent cells, BRL) were transformed with pBR322 as follows. A 50  $\mu$ l aliquot of DH5a cells was placed into a chilled microcentrifuge tube. Three  $\mu$ l pBR322 (0.1  $\mu$ g/ml) was added and mixed by moving the pipette through the cells while dispensing. The cells were incubated on ice (30 min.) and then heat shocked at 37°C (20 seconds). S.O.C. medium (0.95 ml; 2% Bactotryptone, 0.5% yeast extract, 10 mM NaCl, 2.5 mM KCl) was then added and the suspension was shaken (225 rpm; 37°C) for one hour. Finally, the cells were plated on LB tetracycline plates (12.5  $\mu$ g/ml) and incubated overnight (37°C).

To prepare for electrophoresis, cells were grown in 20 ml lactose broth (Difco) to an optical density of 0.5 (520 nm; Bausch and Lomb Spectronic 21) in a 300 ml nephelo culture flask (Kontes) at 37°C in an incubator/shaker (New Brunswick Scientific). Chloramphenicol was added at a final concentration of 170  $\mu$ g/ml for plasmid amplification and the culture was incubated for 12-16 hours. Cells were harvested by centrifugation (11,000xg; 10 min) and resuspended in 1.5 ml TAE buffer (0.04 M TRIS, 0.02 M acetic acid, 0.0001 M EDTA, pH 8.0). 0.5 ml of the

cell suspension was mixed with an equal volume of molten (45°C) 1.8% agar (Sigma Type VII) in a casting chamber. The chamber was a 1 cm<sup>3</sup> plastic chamber cut from a plastic cuvette and sealed with parafilm. Once polymerized, the agarose was removed from the chamber and cut into 24 blocks which were the same size as the wells in the agarose gel (2x4x3 mm). The small agarose blocks were then placed into test tubes containing the treatment solutions.

Sequential treatment included acetone (Fischer A.C.S, 0°C, 10 min.); lysozyme (1 mg/ml, Sigma, grade 1, 37°C, 60 min.), S.D.S. (Fischer U.S.P., 1% 25°C, 60 min.), RNase (Sigma Type I-AS, 0.2 mg/ml, 37°C, 30 min.); proteinase K (Sigma, Type XI, 0.05 mg/ml, 25°C, 45 min.). All solutions were made with TAE buffer, pH 8.0. When the cells lysed in the blocks this could be seen as a clearing of the agarose.

After treatment, the blocks were placed into the wells of a 0.9% agarose (Sigma Type I: low EEO) gel. We used 9.5x7.5 cm casting chambers (Fotodyne Fotophoresis 1 system or Hoefer model HE33). Bromophenol blue (4 µl) and 4 µl of supercoiled standards (BRL, 2.067-16.210 kB) were incorporated into one well. The gel was run at 75 V for 15 minutes and then at 120 V for approximately 90 minutes or until the tracking dye had reached the end of the gel. Gels were stained (45 min.) in 5 µg/ml ethidium bromide in TAE.

## RESULTS

Results of this procedure were compared with an alkaline lysis and chemical extraction method of plasmid preparation (Maniatis *et al.*, 1982). Banding patterns produced by both methods were similar (Figure 1). When untreated blocks were placed into the wells, all detectable DNA remained in the well. The leading band was calculated to be  $4.5 \pm 0.1$  kB in relation to the supercoiled standards. The published size for this plasmid is 4 kB (Bolivar *et al.*, 1977). Other bands are due to nicked and linear DNA. The poorly defined band which appears in the embedded cell preparations with both the plasmid containing and plasmid-free *E. coli* (Figure 1; lanes 2, 3 and 4) is presumably due to fragments of chromosomal DNA, possibly degraded by nucleases during preparation of the blocks.

Since the appearance of the chromosomal DNA band could cause interference with plasmid detection in some cases, a protocol was also developed to remove it. This procedure involved precipitation of linear DNA fragments with sodium acetate (Birnboim and Dolby, 1977). In addition to the previously described steps used for block treatment, an additional treatment step (sodium acetate 3M, pH 4.8; 60 min, 0°C) was included. This effectively removed the chromosomal DNA band, but it apparently also precipitated some plasmid DNA since plasmid bands were not as bright. Because this step adds time to the procedure and decreases plasmid yield, it should only be used when the chromosomal band is likely to interfere with plasmid bands.

To determine the relative efficiency of DNA extraction by this method, lanes from a photographic negative of the gel shown (Figure 1) were scanned using a laser scanning densitometer (Pharmacia/LKB Ultrascan XL). Peak areas corresponding to the plasmid bands in the gel were compared. Plasmid bands resulting from the alkaline lysis method had peak areas of  $0.134 \pm 0.014$  and  $0.037 \pm 0.0075$  AU\*mm. Corresponding bands resulting from this procedure had peak areas of  $0.355 \pm 0.0005$  and  $0.1745 \pm 0.0085$  AU\*mm, respectively. The number of bac-



terial cells used to produce the bands (Fig. 1) are  $1 \times 10^7$  for the miniprep method and  $2.1 \times 10^7$  for this method. When corrected for the difference in cell numbers, the increase in extraction efficiency for this method was 1.3 fold for the circular or linear plasmid form and 2.2 fold for the supercoiled form.

The method was also tested with a gram positive bacterium, *Bacillus subtilis*. The only modification of the procedure which was necessary in this case was to increase the lysozyme concentration (5 mg/ml). A bacillus strain (ATCC 37014) containing plasmid (pSA2100) was obtained and the plasmid was isolated by this procedure. The plasmid band corresponds to a molecular size of  $7.8 \pm 0.1$  kB; the published plasmid size is  $7.4 \pm 0.3$  kB (Gryczan *et al.*, 1978).

### CONCLUSIONS

This method is a convenient alternative to more traditional approaches to plasmid analysis and has the advantages of less sample preparation time and of not requiring tedious chemical fractionation involving toxic solvents. An additional advantage is that reduced handling results in higher plasmid yields. One potential drawback of the method is a somewhat decreased resolution, since the width of the plasmid band is apparently determined by the block size. This could be overcome to some extent by using smaller blocks or by use of lower percent agarose in the casting blocks.

### LITERATURE CITED

- Birnboim, H.C. and J. Dolby. 1977. A rapid alkaline extraction method for the isolation of plasmid DNA. *Meth. Enzymol.* 100:243-255.
- Bolivar, F., R.L. Rodriguez, D.J. Greene, M.C. Betlach, H.L. Heyneker, H.W. Boyer, J.H. Crosa and S. Falkow. 1977. Construction and characterization of new cloning vehicles: II. A multipurpose cloning system. *Gene* 2:95-113.
- Brick-Miller, T. 1986. Solid phase extraction of mammalian cell mitochondrial DNA and its electrophoretic separation in agarose gels. M.S. Thesis. Old Dominion University.
- Gryczan, T.J., S. Contente and D. Dubnau. 1978. Characterization of *S. aureus* plasmids introduced by transformation into *B. subtilis*. *J. Bacteriol.* 134:318-329.
- Heath, L.S., G.L. Sloan and H.E. Heath. 1986. A simple and generally applicable procedure for releasing DNA from bacterial cells. *Appl. Environ. Microbiol.* 51:1138-1140.
- Kado, C.I. and S.T. Lui. 1981. Rapid procedure for detection and isolation of large and small plasmids. *J. Bacteriol.* 145:1365-1373.
- Maniatis, T., E.F. Fritsch and J. Sambrook. 1982. *Molecular Cloning: A laboratory manual*. 545 pages. Cold Spring Harbor Laboratory, New York.
- Schwartz, D.C. and C.R. Cantor. 1984. Separation of yeast-sized DNAs by pulsed field gradient gel electrophoresis. *Cell* 37:67-75.



## A Diallel Study of Stalk Rot Resistance in Elite Maize and its Interaction with Yield

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### ABSTRACT

Stalk rot of maize (*Zea mays*) and its effect on yield was studied using 11 elite inbred parents (A619, A632, B73, H93, H96, Mo17, Oh7B, Pa91, Va17, SS419, Va85) and all possible single crosses among them. The experimental design was a split-plot with two stalk rot pathogens (*Diplodia maydis* and *Fusarium moniliforme*) and a control being the three whole plots and the inbreds and hybrids described above the split plots. Plants were inoculated approximately three weeks following silking. Yield and stalk rot scores were taken at maturity. Analyses of variance and general(GCA) and specific(SCA) combining ability analyses were performed on stalk rot scores and grain yield. There were no significant differences between the two pathogens for mean stalk rot score, but both were significantly higher in score than the control. Differences among the whole plots for mean yield were not significant. Hybrid/inbred by pathogen interactions were not significant for yield or stalk rot scores, indicating that the inbreds and their hybrids performed consistently across the pathogens and control. The estimates of GCA and SCA effects for stalk rot score both were significant with the GCA effects being the greater. Individual plant yields were not affected by the stalk rot pathogen inoculations. Two Virginia lines, Va17 and Va85, were found to have both high yield and high levels of resistance to stalk rot.

### INTRODUCTION

Hybrid maize (*Zea mays* L.) is one of plant breeding's modern success stories. Maize hybrids are better yielding than ever. The dual effects of improved fertilization practices and intensive use of genetics and plant breeding have raised the national average maize yields from around 15 q/ha in 1935 to around 54 q/ha in 1975 (Hallauer and Miranda, 1981). Since high yield results from favorable interaction of many inherent traits and environmental factors, modern maize has had many traits other than yield improved.

Stalk lodging has long been recognized as a problem in maize production. Although Schweinitz in 1834 was the first person to describe *Diplodia maydis* (Berk.) Sacc. [syn. *D. zeae* (Schw.) Lev.] on maize (Christensen and Wilcoxson, 1966), it was not until 1896 and 1904 that the losses due to the various aspects of stalk rot were assessed. Along with Peters (1904), Moore (1896) called attention

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to a widespread disease of cattle and other animals known as the "stalk rot" disease. This disease occurred chiefly in the fall and early winter when cattle were feeding on maize stalks in the field. While working with Peters, Sheldon (1904) suggested that the "stalk rot disease" of cattle was caused by a *Fusarium* sp. and named it *Fusarium moniliforme* Sheldon.

On-farm estimates of losses have ranged from a direct loss in Ohio of 10-15%, plus an additional loss due to non-harvested ears, ear rots, and harvesting difficulties (Williams and Schmitthenner, 1963) to losses between 15-20% of the crop (Roane, 1950). Because of these losses, standability continues to be one of the more important traits evaluated by farmers when they select maize hybrids. Perry (1983) and McClane (1985) studied rind thickness and yield components and how these traits performed in a diallel cross of 12 elite inbred lines. These lines were chosen because they are widely used in maize hybrids grown commercially by American farmers. In this study we evaluated how stalk rot reaction *per se* is inherited and whether or not stalk rot resistance differs between two stalk rot pathogens.

Many researchers have noted the relationship between stalk sugar levels and stalk rot. Both Morris (1931) and Sayre *et al.* (1931) found that the total sugar in maize stalks reaches a peak about one week before fertilization and decreases toward maturity. Barren plants were usually resistant to stalk rot. Removal of leaves reduced sucrose content of the stalks. This has been confirmed by others (Holbert *et al.*, 1935; Deturk *et al.*, 1937; Messiaen, 1957; Craig and Hooker, 1961; Mortimore and Ward, 1964). Related to this, Pappelis (1965) made the observation that pith cell death precedes stalk rot. Hooker (1973) stated that the stalks that maintain a state of tissue hydration longest during the grain filling period are the most resistant to stalk rot.

Sprague (1954) and Hooker (1957) noted that reaction of maize to *D. maydis* provided a measure for resistance of stalk rot in general. Christensen and Wilcoxson (1966) also made the observation that there is evidence that maize is very resistant to *Gibberella zeae*, *D. maydis*, and other species until about silking. Several experiments dealing with selection for lodging resistance have been conducted over the years. Thompson (1970 and 1982) published papers on recurrent selection for stalk quality. Selection was effective in both directions.

Dodd (1983) summarized the stalk rot literature and concluded that maize is among the most efficient species in capturing light and converting it to sugar. Since it is a C<sub>4</sub> plant it does not become CO<sub>2</sub>-limited and can utilize full sunlight to produce carbohydrates. During growth phases much of this photosynthate is drawn to growing points in the roots and stem of the plant. Prior to flowering, sugars accumulate in the stalk but after pollination most of the photosynthate is directed to the ear. Without stress each kernel draws a daily amount of sugar during grain development. If for various reasons the amount of photosynthate is limited, then the sugar is drawn from the stalk. Some of the effects of this switch are as follows: 1) aging of the cells in the leaves, stalk and roots begins; 2) root growth stops; 3) lacking basic metabolites roots lose the ability to produce biochemicals to ward off weak soil microorganisms (Dodd, 1980); 4) the population of fungi around the roots increases; and 5) this imbalance toward the ear leads to a rapid deterioration of the roots, providing an avenue for infection.



TABLE 1. Pedigree and origin for the lines used in the diallel cross made in 1984.

LINE	PEDIGREE	ORIGIN
A619	(A161 X OH43)OH43	MINNESOTA
A632	(MT42 X B14)B14 BC2	MINNESOTA
B73	IOWA STIFF STALK SYN. C5	IOWA
H93	(B37 X GE440)B37BC4Ht	INDIANA
H96	(H55 X H56)	INDIANA
MO17	(187-2 X C103)	MISSOURI
OH7B	(OH07 X 38-11)OH07	OHIO
PA91	(WF9 X OH40B)S4) X (IND38-11 X L317)IND38-11S4	PENNSYLVANIA
SS419	SOUTHERN SYNTHETIC A	VIRGINIA (UNRELEASED)
VA17	(WF9 X T8)	VIRGINIA
VA85	VA. LONG EAR SYN.	VIRGINIA

Stalk rot is a dynamic interaction between photosynthetic stresses (nutrients, water, heat, disease, insects) and translocation imbalances. Although pathogens are necessary to do the rotting, they are rarely the variable accounting for the distribution of stalk rot; it is the host-environment interaction that is critical. Stalk rotted plants often have more kernels than non-stalk rotted plants in the same field. Plants with higher kernel numbers will be the first to show stalk rot because they will have a higher translocation demand on the stalk and will be the first to show the symptoms of stalk deterioration.

#### MATERIALS AND METHODS

Eleven elite inbred maize lines were crossed in all possible combinations at the Eastern Virginia Agricultural Experiment Station, Warsaw, Virginia in 1984. Equal amounts of F<sub>1</sub> seed were bulked from each reciprocal cross to eliminate possible maternal effects. The lines were selected because of their wide use in commercially available hybrids. All of the lines in the diallel except for SS419 have been used to formulate commercially available hybrid corn. The source of the inbreds is given in Table 1 (Henderson, 1984).

All 55 hybrids produced and the 11 parent inbreds were planted at Warsaw, Virginia with a ALMACO (Ames, IA) cone planter on May 7, 1985. Seventy-five seeds were planted in 6.1m rows. When the growing points of the plants had emerged from the ground (growth stage 4; Honway, 1966), rows were thinned to a uniform spacing and population of 59,280 plants/ha. Seed was planted in a split plot design with stalk rot pathogens being the whole plots (non-inoculated, inoculated with *F. moniliforme*, and inoculated with *D. maydis*) and each inbred or hybrid being a sub-plot. There were three whole-plots and 66 sub-plots with three replications.

The soil, a Kempsville loam, was fertilized with 125.5 kg/ha of N, 126.6 kg/ha P<sub>2</sub>O<sub>5</sub>, and 156.9 kg/ha K<sub>2</sub>O at planting and an additional 123.2 kg/ha of N was



applied at thinning as a 30% nitrogen solution. Atrazine (Triazine) and Alachlor (Acetanilide) were applied preplant at the labelled rates for weed control.

The plots were divided into two groups based on silking date: an early and a late group. This was done to avoid any confounding effects with maturity as plots were inoculated three weeks after the mean pollination date for each group.

*D. maydis* and *F. moniliforme* were chosen as stalk rot pathogens for this study because they are two of the most common stalk rot organisms found in Virginia. Inoculum was prepared from a single spore culture isolated from infested maize kernels collected from the field. The pathogen isolates were grown on nutrient agar. Toothpicks were then infested with one of each pathogen according to the methods of Christensen and Wilcoxson (1966) modified with the addition of sucrose to the medium to enhance fungal growth.

Ten plants in each inoculated plot had their rinds' punctured at the third internode from the ground and were inoculated by inserting toothpicks infested with either *D. maydis* or *F. moniliforme*. The non-inoculated controls had their internodes punctured but did not have infested toothpicks inserted. Four weeks after inoculation stalks of all plants were split and rated for the spread of stalk rot. A mean value for the ten plants was calculated as the rating for the plot.

The rating system used was as follows: 1- very little spread of stalk rot in the internode; 2- internode was generally rotted, but the rot remained in a single internode; 3- stalk rot crossed one internode; 4- stalk rot crossed two internodes and continued up the plant, but the plant was still alive; 5- general stalk rot with plant dead. Ears were harvested from plants scored for stalk rot, and were shelled, weighed, and a mean grain in grams/plant/plot was calculated, adjusted to 15.5% moisture.

### STATISTICAL METHODS

Data from the experiment were analyzed as a split-plot design, with stalk rot treatments as whole plots and hybrids or inbreds being the sub plots. Analyses of variance (ANOVA) were calculated using the mean of ten observations for each trait using the ANOVA procedure of Statistical Analysis Software (SAS) package (SAS Institute, Inc., Cary, NC 27511). The appropriate error terms were used to calculate significance as determined by the F-test based on the expected mean squares.

Missing plots were calculated using the estimation technique of multiple analysis of covariance (Coons, 1957) as adapted by Hinkelmann (1968) to diallel experiments. The error degrees of freedom were not reduced for the number of missing plots because they did not substantially change the significance tests.

Model I analysis of Eisenhart (1947) along with Method 4 of Griffing (1956) was used to calculate the combining ability analysis (general combining ability (GCA) and specific combining ability (SCA)). No reciprocals or parents were used in this analysis so that comparisons could be made with the work of Perry (1983) and McClane (1985). This analysis assumes that all factors except error are fixed (the lines used were not a random sample).

The computer program used to calculate the combining ability analysis was written by Schaffer and Usanis (1969). Combining abilities are as defined by Sprague and Tatum (1942). This analysis is a least squares method.

TABLE 2. ANOVA for stalk rot scores with inbred lines included.

SOURCE	DF	MEAN SQUARE	F VALUE
BLOCKS	2	3.9037	2.95
PATHOGENS	2	35.8477	27.08*
ERROR A	4	1.3233	
HYBRIDS/LINES	65	4.9390	10.60*
PATHOGEN X HYBRID	130	.5095	1.09
ERROR B	390	.4661	
R-SQUARE .722			
CV 23.36			

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\*Significant at the .05 level

Estimates of variance components were calculated based on a completely random model (Model II of Eisenhart). This was done in order to get an estimate of the heritabilities. Narrow-sense heritability estimates for the characters were calculated from estimates of the variance components using the Hallauer and Miranda (1981, p.63) formula modified for completely inbred parents.

### RESULTS AND DISCUSSION

Rainfall amounts in the beginning and middle of the growing season at the Warsaw experiment station were below normal. Emergence was delayed and the experiment displayed symptoms of drought stress throughout pollen shed for both maturity groups. Because of this, yields for the hybrids and inbreds were likely depressed. Since drought stress is a frequent problem in the Southeast, these results reflect a common occurrence. Temperature levels were typical for the season. Roughly one-half of the hybrids fell into each maturity group.

Inbred lines were included in the experiment to estimate how inbred response was reflected in their hybrids. The estimates of GCA and SCA effects that Perry (1983) and McClane (1985) made using the same diallel did not include parents. For this reason, GCA and SCA effects in this study were calculated also using the analysis without inbred lines. This allows comparisons among the results of the three studies with this same diallel.

The ANOVA table for stalk rot score is given in Table 2. Despite some field variation there was not a significant block effect. The pathogen treatment effects were significant, with an F-value of 27.09. Table 3 shows the source of this significance. The control (non-inoculated) with a mean stalk rot score of 2.44 was significantly different from both the *D. maydis* (3.24) and *F. moniliforme* (3.09) treatment scores. The *D. maydis* and *F. moniliforme* treatments were not significantly different from each other. Table 4 (inbred lines omitted) confirms this result with a significant pathogen F-value of 31.19. Block effects were also significant with an F-value of 4.46 reflecting variation most likely caused by the drought stress and its interaction with soil conditions.

TREATMENT	OBSERVATIONS	SCORE*
CONTROL	198	2.44a
<i>D. maydis</i>	198	3.24b
<i>F. moniliforme</i>	198	3.09b

SOURCE	DF	MEAN SQUARE	F VALUE
BLOCKS	2	5.7976	4.46*
PATHOGENS	2	40.5034	31.19*
ERROR A	4	1.2987	
HYBRIDS	54	2.9147	10.60*
GCA	10	10.6298	23.38*
SCA	44	1.1612	2.55*
PATHOGEN X HYBRID	130	.4644	1.00
ERROR B	390	.4661	

CV 24.57

inbred line	Inbred line									
	A632	B73	H93	H96	MO17	OH7B	PA91	SS419	VA17	VA85
A619	2.14	2.98	2.34	2.48	2.69	2.91	2.66	2.91	2.22	1.99
A632		2.99	2.76	3.06	2.91	2.90	2.66	2.93	2.32	2.34
B73			2.72	2.57	3.49	4.40	2.76	2.54	2.61	1.91
H93				2.51	2.27	2.42	2.39	2.58	2.00	1.80
H96					3.37	4.37	3.24	3.91	2.92	2.42
MO17						3.03	2.22	3.37	2.07	2.14
OH7B							3.31	3.78	3.09	3.06
PA91								3.14	2.93	2.33
SS419									2.31	2.18
VA17										2.06
								MEAN		2.74



The inbred line and/or hybrid scores for stalk rot, averaged over inoculated treatments were significantly different as shown in Tables 3 and 5. The F-values were 10.60 including inbred lines and 6.46 excluding lines. In both cases the inoculation treatments by hybrid interaction were not significant, having an F-value of 1.09 including inbred lines and 1.00 excluding them. This suggests that if an inbred line or hybrid shows resistance to one of these pathogens in a breeding nursery, it will likely be resistant to the other stalk rotting pathogens. Also stalk rotting scores in the wounded, non-inoculated control remained at the same relative levels as when it was inoculated with one of the pathogens. This has important consequences in managing a breeding program. If an inbred line shows resistance in the nursery to one of these pathogens then further testing may not be necessary for the other stalk rotting pathogens.

This observation also corroborates the suggestion that others have made (Dodd, 1983; Mortimore and Wall, 1965) that resistance may have more to do with the partitioning of photosynthate in the plant itself and less to do with the particular stalk rotting pathogen since these are very weak pathogens and colonize dead or dying tissues. Selection of "stay green" stalk types may help in identifying stalk rot resistant plants for breeding programs since stalks stay green as a result of continued production of photosynthate by the plant.

When the hybrid effects shown in Table 4 are sub-divided into SCA and GCA effects, both are significant. The F-value for SCA effects (2.55) was much lower than that for the GCA effect at 23.38, showing that more of the hybrid variation for stalk rot was controlled by additive gene action as opposed to other types of gene action (epistasis, overdominance, pseudo-overdominance, etc.) and that this trait is highly heritable. Indeed, calculation of a conditional heritability based on these results shows it to be moderately high at  $0.644 (\pm 0.003)$ . This indicates that selection for stalk rot resistance in a breeding nursery will be effective.

Mean stalk rot scores for the hybrids based on nine observations (three replications x three whole plots) are given in Table 5. Hybrid B73 x Oh7B had the highest stalk rot mean score of 4.40. This score indicates that most of the plants were completely stalk rotted and almost half of the plants were dead. Lodging in this case was severe. Hybrid B73 x Mo17 had a score of 3.49 which was well above the mean for all hybrids, which was 2.74. This hybrid at one time was one of the more common hybrids grown in the U.S. (unpublished). Several of the Va85 hybrids had scores below 2.0, showing that among these hybrids there was little advancement of the pathogen within the stalk. These hybrids also had stalks that remained green throughout the rating period indicating that the stalks continued to receive adequate levels of sugar to maintain pith cell life. Several of these hybrids also had high yield levels

Mean stalk rot scores for the inbred lines and their GCA effects are given in Table 6. Two of these lines, Va17 and Va85, showed negative (better than many inbred lines) GCA effects for stalk rot with scores of -0.313 and -0.568, respectively. They also had low mean scores for stalk rot resistance (2.98 and 1.89, respectively). The correlation between the GCA effects and the inbred line score for stalk rot was  $r = 0.72$ , which was significant at the 0.05 level. This indicates that some of these inbred lines and especially Va85 would make good parents in a maize improvement program that stressed stalk rot resistance. Low GCA effects for this trait indicate

TABLE 6. Mean stalk rot scores of lines and their GCA effects (Warsaw, Virginia 1985).

Line	GCA	SCORE
A619	-.225	4.21
A632	-.037	4.16
B73	.180	4.71
H93	-.395	3.88
H96	.389	4.68
MO17	.023	3.82
OH7B	.658	4.30
PA91	.033	3.64
SS419	.256	4.15
VA17	-.313	2.98
VA85	-.568	1.89

TABLE 7. SCA effects for stalk rot score of hybrids from eleven inbreds grown at Warsaw, Virginia 1985.

Inbred line	Inbred line									
	A632	B73	H93	H96	MO17	OH7B	PA91	SS419	VA17	VA85
A619	.33	.29	.23	-.42	.16	-.26	.11	.15	.03	.05
A632		.11	.45	-.03	.19	-.46	-.07	-.02	-.06	.22
B73			.20	-.74	.55	.83	-.19	-.63	.0	-.44
H93				-.22	-.10	-.58	.02	-.02	-.03	.03
H96					.22	.59	.09	.53	.11	-.13
MO17						-.38	-.57	.35	-.38	-.05
OH7B							-.11	.13	.01	.23
PA91								.12	.48	.13
SS419									-.37	-.25
VA17										.20

that the inbred characteristic is transmitted to the progeny at a high level. Other lines that had a negative GCA effect were H93, A619, and A632. The inbred A632 had a GCA effect of -0.047 and an inbred stalk rot score of 4.16. This level is not high enough for it to be considered as a parent in a line improvement program stressing stalk rot resistance. The other two lines, A619 and H93, had GCA effects of -0.225 and -0.395, respectively. The mean stalk rot score for H93 was 3.88 and for A619 was 4.21. A619 is an early inbred from Minnesota. This would suggest that maturity is not a problem in selection of stalk rot resistant lines.

Table 7 lists the SCA estimates for the crosses of the diallel. Hybrid B73 x Mo17 had a SCA effect of 0.551, indicating that it performed worse than would be expected based on the inbred stalk rot scores. This hybrid has very high yield, which



TABLE 8. ANOVA for shelled grain weight in grams per plant with inbred lines included, for diallel grown at Warsaw, Virginia 1985.

SOURCE	DF	MEAN SQUARE	F VALUE
BLOCKS	2	145849.5017	6.13*
PATHOGENS	2	5848.7340	.25
ERROR A	4	23801.3956	
HYBRIDS/LINES	65	12857.0059	10.85*
PATHOGEN X HYBRID	130	1039.2742	.88
ERROR B	390	1184.5694	

R-SQUARE .75

CV 37.74

\*Significant at the .05 level

evidently made up for the poor stalk performance when this hybrid was widely used. Hybrid B73 x Pa91, another widely used hybrid, had a SCA effect of -0.192, indicating that this hybrid performed better than expected based on the parental values.

Table 8 shows the ANOVA for grain in grams/plant and includes the inbred lines. Differences among pathogen treatments were not significant. This is a very important result. There were no significant differences between the control (non-inoculated) and the inoculation with either *D. maydis* or *F. moniliforme*. The presence of these pathogens did not significantly lower yields. There was also no significant difference in the relative amounts of stalk rot caused by the two pathogens on the inbreds and hybrids. This further indicates that selection for resistance to one pathogen in this elite germplasm will also give resistance to the other. It also suggests that resistance is likely a function of photosynthetic partitioning by the maize plant. This result is in agreement with the results of others (Dodd (1980), Pappelis (1965), and Christensen and Wilcoxson (1966)) who have looked at stalk rot reaction. Selection of plants that continue to send adequate levels of sugar to the stalk should give a high level of resistance to stalk rot pathogens.

The F-value of 10.85 for hybrids/lines as given in Table 8 was significant. This analysis includes inbred lines so this F-value is higher than that shown for hybrids in Table 9 (F-value = 2.92) which had the inbred lines removed. The low yield of inbreds vs. hybrids contributed to this higher F-value in Table 8. There was not a significant hybrid x pathogen interaction for yield. This would indicate that the hybrids and inbreds behaved similarly across the inoculated treatments.

In Table 9, block and pathogen F-values were 5.96 and 0.25, respectively. This is not very different from the corresponding F-values in Table 8 of 6.13 and 0.25, respectively. The F-value for hybrids in Table 9 was different from the F-value for hybrids/inbred lines in Table 8 and this is due to the lower yield of inbreds vs. hybrids. The GCA effects, shown in Table 9, were significant with an F-value of 9.04 and the SCA effects were also significant with an F-value of 1.55. The relative differences in GCA and SCA effects for grain yield were similar to the results of McClane (1985) and Perry (1983) where a majority of the effects were determined



TABLE 9. ANOVA for shelled grain yield in grams per plant, with inbred lines excluded, for the diallel grown at Warsaw, Virginia 1985.

SOURCE	DF	MEAN SQUARE	F VALUE
BLOCKS	2	159539.0687	5.96*
PATHOGENS	2	6784.1051	0.25
ERROR A	4	26790.9626	
HYBRIDS	54	3540.3024	2.92*
GCA	10	10894.1921	9.04*
SCA	44	1868.9639	1.55*
PATHOGEN X HYBRID	108	1187.1339	.98
ERROR B	390	1211.2655	

R-SQUARE .66

CV 32.89

\*Significant at the .05 level

TABLE 10. Mean shelled grain yield in grams per plant for pathogen treatments, averaged over both hybrids and inbreds.

TREATMENT	OBSERVATIONS	G/PLANT <sup>1</sup>
CONTROL	198	93.31a
<i>D. maydis</i>	198	85.03a
<i>F. moniliforme</i>	198	95.25a

<sup>1</sup>Treatments with the same letter are not significantly different at the .05 level.

to be of an additive nature. Heritability for yield was 0.518 ( $\pm$  0.05) and this compares with 0.55 in the studies by both McClane and Perry. The F-value for pathogen x hybrid interaction (Table 9) was 0.98.

The mean yields for the inoculated and non-inoculated treatments (whole-plots), averaged over inbreds and hybrids, are given in Table 10. As stated above, they were not significantly different. The mean yields in g/plant for the non-inoculated control, the *D. maydis*, and the *F. moniliforme* inoculation were 93.31, 85.03, and 95.25, respectively.

Table 11 lists the yields of the hybrids in g/plant. The best hybrid in the experiment was the Va85 x Oh7B cross which had a per plant yield of 155 grams. This was followed by the A632 x Oh7B cross which had a mean yield of 141 g/plant. One of the most widely used hybrids, B73 x Mo17, had a yield of 122 g/plant. A hybrid that had a high yield (126 g/plant) along with a low stalk rot score (1.91), was Va85 x B73. This hybrid seemed to be able to overcome the poor stalk quality that was present in most B73 derived hybrids. The lowest yielding hybrid (68 g/plant) was Pa91 x A619. This is to be expected since both inbreds are of a similar heterotic pattern. A surprising result was the low yield of B73 x Pa91. This hybrid has been

TABLE 11. Mean shelled grain yield in grams per plant averaged over three replications and three whole-plots for all possible hybrid combinations of eleven inbreds grown at Warsaw, Virginia 1985.

Inbred line	Inbred line									
	A632	B73	H93	H96	MO17	OH7B	PA91	SS419	VA17	VA85
A619	88	120	57	119	82	124	68	86	102	69
A632		115	93	115	84	141	85	73	112	112
B73			95	118	122	117	96	93	124	126
H93				110	97	107	106	105	111	117
H96					130	125	116	116	128	128
MO17						123	68	74	99	122
OH7B							110	101	111	155
PA91								108	120	108
SS419									83	97
VA17										110
									MEAN	106

TABLE 12. Mean shelled grain yield of lines in grams per plant and GCA effects.

Line	GCA	YIELD(g/PLANT)
A619	-15.96	4.44
A632	-4.52	15.00
B73	7.37	13.22
H93	-6.81	17.44
H96	16.40	17.56
MO17	-6.26	20.33
OH7B	17.34	27.22
PA91	-8.17	39.56
SS419	-13.50	4.56
VA17	4.63	12.11
VA85	9.48	27.67

widely sold in the U.S. (unpublished data) and the low yield in this experiment confirms its susceptibility to drought.

Table 12 lists mean inbred yield in g/plant and the inbred line GCA effects. Inbred Oh7B had the highest GCA effect of 17.34 and had a inbred yield of 27.22 g/plant. Unfortunately, this inbred also had the poorest stalk quality GCA. The inbred with the highest inbred yield was Pa91 with a yield per plant of 39.56g. Inbred Pa91, however, had a negative GCA for yield, showing that unlike stalk quality there was little correlation between inbred traits and hybrid GCA effects ( $R = .34$  ns). These results duplicate the findings of many other researchers which

show low correlations between inbred and hybrid yield traits. These results indicate that selection for inbred yield is not effective in selection for hybrid performance.

Two hybrids which had positive (good) GCA effects for yield and negative (good) GCA effects for stalk quality were Va17 and Va85. Va85 had a GCA effect of 9.483 and a yield of 27.67 g/plant; Va17 had a GCA effect of 4.63 and a yield of 12.11 g/plant. Both of these lines are good candidates for an improvement program for inbreds, having apparently broken any linkages which might exist between good yield and poor stalk performance.

Hybrid Oh7B x Va85 showed a high SCA effect for yield of 22.80; this hybrid, unfortunately, had a high stalk rot SCA of 0.231 which was worse than average for the test. Hybrid B73 x Va85 also had a positive SCA effect of 3.43 for yield and a negative (better) SCA effect for stalk rot score of -0.435, which would indicate that this hybrid has potential for use in areas where stalk rot is common. Hybrid B73 x Mo17 had a SCA effect of 15.28 for yield and a SCA effect of 0.551 for stalk quality. Since this hybrid is grown over a wide area, it is surprising that it had such a poor SCA effect for stalk score. In general, those hybrids which have a high SCA for yield are those which have been used in hybrid production. This indicates the importance of SCA effects on the selection of hybrids for production and suggests that many of these hybrids are making use of non-additive gene action. McClane (1985) discusses this in greater detail in his dissertation dealing with other aspects using these same inbred lines.

Our results suggest that standability is affected by several traits that interact throughout the growing season. This accounts for the problems in getting a good estimate of stalk quality. Dodd (1983) discusses many of these factors. In this study we also show that stalk rot score is an important trait related to hybrid standability. This trait appears to be linked with photosynthate partitioning. In years where the leaf area is prematurely destroyed, this becomes increasingly important. In other studies with the gray leaf spot disease, caused by *Cercospora zeae-maydis*, an increase in lodging is seen with losses of leaf tissue (Stromberg and Donahue, 1986). Any factor that lowers the level of sugar in the stalk increases stalk lodging. Stalk rot scores appear to be an accurate measure of the potential for lodging in hybrid genotypes. In cases where the plant is killed prematurely by frost or disease, the best measure of stalk quality would be the stalk strength as measured by rind thickness.

The correlation between stalk rot score and grain yield in grams per plant was not significant ( $r = 0.25$ ). Two Virginia lines, Va17 and Va85 were shown to have positive GCA estimates for yield and negative (good) GCA estimates for stalk quality. The fact that stalk rot score is not strongly negatively correlated with yield means that selection can easily be done simultaneously for these two traits.

Since there are two or more differently inherited traits involved in standability, it is not surprising that it has been difficult to account for annual variations in stalk lodging. In northern maize growing areas where it is common for frost to kill the plant, rind thickness is probably more important as a selection criteria. In the southern maize growing areas, however, where frost rarely kills the maize plant prematurely, the "stay green" and leaf blighting resistance characters become more important.



## ACKNOWLEDGEMENTS

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## LITERATURE CITED

- Christensen, J. J., and R. D. Wilcoxson. 1966. Stalk Rot of Corn. Phytopathology Monograph No. 3. The American Phytopathological Society. The Hoffman Press, Inc., Worcester, Mass. 59pp.
- Coons, I. 1957. The analysis of covariance as a missing plot technique. *Biometrics* 13:387-405.
- Craig, J., and A.L. Hooker. 1961. Relation of sugar trends and pith density to Diplodia stalk rot in dent maize. *Phytopathology* 51:376-382.
- Deturk, E.E., E.B. Earley, and J.R. Holbert. 1937. Resistance of corn hybrids related to carbohydrates. *Illinois Agr. Exp. Sta. Ann. Rept.* 49:43-45
- Dodd, J.L. 1980. The role of plant stresses in development of corn stalk rots. *Plant Disease* 64(6):533-537.
- Dodd, J.L. 1983. Corn stalk rot: accounting for annual changes. 38th Annual Maize & and Sorghum Research Conference, American Seed Trade Association, Washington, No. 38 p.71-79.
- Eisenhart, C. 1947. The assumptions underlying the analysis of variance. *Biometrics* 3:1-21.
- Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. *Australian J. Biol. Sci.* 9:463-493.
- Hallauer, A. R., and J. B. Miranda. 1981. Quantitative genetics in maize breeding. Iowa State Univ. Press. Ames, Iowa. 468 pp.
- Hinkelmann, K. 1968. Missing values in partial diallel cross experiments. *Biometrics* 24:903-913.
- Holbert, J.R., P.E. Hoppe, and A.L. Smith. 1935. Some factors affecting infection with and spread of *Diplodia zeae* in the host tissue. *Phytopathology* 25:1113-1114.
- Honway, J.J. 1966. Spec. Rep. 48. Iowa State University Press.
- Hooker, A.L. 1956. Association of resistance to seedling, root, stalk, and ear diseases in corn. *Phytopathology* 66:379-384.
- Hooker, A.L. 1957. Factors affecting the spread of *Diplodia zea* in inoculated corn stalks. *Phytopathology* 67:196-199.
- Hooker, A.L. 1973. New developments in the corn leaf and stalk disease picture. Proc. 28th Corn Res. Conf., pp. 62-71. Am. Seed Trade Assoc.
- McClane, J. M. 1985. Diallel study of flowering and ear components of yield in Corn Belt maize and their interactions with population density. Ph.D. Diss. Virginia Polytechnic Institute and State University. 171 pp.
- Messiaen, C.M. 1957. Richesue en sucre des tiges de mais et verse parasitaire. *Rev. pathol. vegetale et entomol. agr. France* 36:209-213.

- Moore, V.A. 1896. Cornstalk disease, and rabies in cattle. U.S. Dept. Agr. Bur. Anim. Ind. Bull. 10.
- Morris, V.H. 1931. Effect of barrenness and reduction of leaf area on the sugar content of corn stems. Ohio Agr. Exp. Sta. Bull. 470:23-24.
- Mortimore, C.G., and L.F. Gates. 1969. Effects of reducing interplant competition at different stages of growth on stalk rot and yield components of corn. Can. J. Plant Sci. 49:723-729.
- Mortimore, C.G., and R.E. Wall. 1965. Stalk rot of corn in relation to plant population and grain yield. Can. J. Plant Sci. 45:487-492.
- Mortimore, C.G., and G.M. Ward. 1964. Root and stalk rot of Southwestern Ontario. III. Sugar levels as a measure of plant vigor and resistance. Can. J. Plant Sci. 44:451-457.
- Pappelis, A.J. 1965. Relationship of seasonal changes in pith condition ratings and density to Gibberella stalk rot of corn. Phytopathology 55:623-626.
- Pappelis, A. J., and O. Meyers, Jr. 1970. Parenchyma Cell death patterns in the stalk, shank, cob and midrib of corn. Agron. Abstr., American Society of Agronomy, Madison, WI. p27.
- Perry, C. O. 1983. Diallel analysis of rind puncture and grain yield and their interactions with plant densities for twelve elite inbred lines of maize, *Zea mays* L. Ph.D. Diss. Virginia Polytechnic Institute and State University. 180 pp.
- Peters, A.T. 1904. A fungus disease in corn. Nebraska Agr. Exp. Sta. 17th Ann. Rept. p.13-22.
- Roane, C.W. 1950. Observations on corn diseases in Virginia from 1947 to 1950. Plant Dis. Repr. 34:394-396.
- Sayre, J.D., V.H. Morris, and F.D. Richey. 1931. The effect of preventing fruiting and of reducing the leaf area on the accumulation of sugars in the corn stem. Agron. J. 23:751-753.
- Schaffer, H. E., and R. A. Usanis. 1969. General least squares analysis of diallel experiments: A computer program. Diall. Res. Rep., Genet. Dept., North Carolina State Univ. No. 1.
- Sheldon, J.L. 1904. A corn mold (*Fusarium moniliforme* n. sp.) Nebr. Agr. St. 17th Ann. Rept. p. 23-32.
- Sprague, G.F., and L. A. Tatum. 1942. General vs specific combining ability in single crosses of corn. Agron. J. 43:923-932.
- Sprague, G. F. 1954. Breeding for resistance to stalk rot. American Seed Trade Pub. No. 9:38-43.
- Thompson, D. L. 1970. Recurrent selection for stalk lodging resistance and susceptibility in two populations of corn. Agron. Abstr. American Society of Agronomy, Madison, WI p21.
- Thompson, D.L. 1982. Grain yield of two synthetics of corn after seven cycles of selection for lodging resistance. Crop Sci. 22:1207-1210.
- Williams, L.E., and A.F. Schmitthenner. 1963. Rotation affects corn stalk and root rot. Ohio Agr. Exp. Sta. Farm and Home Res. 48:67-68.



## Lipid Composition of Selected Strains of Channel Catfish Farm-Raised by Different Aquacultural Methods

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### ABSTRACT

The objective of this study was to determine if different strains of channel catfish (*Ictalurus punctatus*), or the aquacultural techniques used for raising them, were significant determinants of muscle or liver fat levels. Catfish strains were Norris Mississippi, Auburn Alabama, James River Virginia and Virginia albino. Each strain was raised in ponds and cages. All fish were fed floating fish nugget twice daily for 90 days at 3% of their estimated body weight. Total lipid samples of the livers and muscles indicated that there were neither significant effects ( $P > 0.05$ ) of strains and culture methods on percent of muscle and liver fat contents nor were there significant effects [ $P > 0.05$ ] of the strain by aquacultural method interactions on cultured channel catfish in Southern Virginia. However, for each strain, livers had significantly greater fat contents than muscles regardless of the aquacultural method (open pond  $P < 0.0002$ ; cage  $P < 0.0075$ ).

### INTRODUCTION

Dietary lipid is the most concentrated source of energy of all the nutrients; it provides 9 kcal/g of digestible energy, about double that contributed by either carbohydrate or protein. Fish use these fat calories to a limited extent for immediate energy but primarily for storage in a compact form. Several studies have shown that by providing adequate lipids to fish, protein can be spared for growth (Ringrose, 1971; Lee and Putnam, 1973; Reinitz *et al.*, 1978; Watanabe, 1982; and Jauncy, 1982).

Total lipid content of channel catfish (*Ictalurus punctatus*) averages 3.6% of a fillet cut, which is related to the consumer recognizable market forms. A fish with greater than 5% body fat generally is considered too oily, and one with less than 5% body fat normally is rated as lean and good for human consumption (Exler *et al.*, 1975). A problem with lipids is that they can become the vehicle for undesirable fat-soluble compounds, *e.g.* pesticides and other agricultural chemicals, in addition to industrial chemicals and flavor compounds (FAO, 1977).

Many studies have shown that strains of certain species of fish are better than others for growth, food consumption, seinability, disease resistance, parasitic load, catchability by hook and line, heat tolerance, etc. Although strain evaluations have been done with channel catfish (Smitherman *et al.*, 1974; Burnside *et al.*, 1975; Plumb *et al.*, 1975; Shrestha 1977; Green *et al.*, 1979; Chappell 1979; Youngblood 1980; Bice 1981; Broussard and Stickney 1981, 1984; Dunham and Smitherman 1981; Horn 1981; Al-Ahmad 1983), none of the studies has dealt with the influences



TABLE 1. Catfish\* population and mortality record in different ponds and pond-cages at Randolph Farm, Virginia State University, Petersburg, Virginia

CULTURE SYSTEM**	FISH POP.	FISH MORT.	%MORT.
Open Pond No. 5	2,700	0	0
Cages in Pond No. 5	320	0	0
Open Pond No. 14	2,700	0	0
Cages in Pond No. 14	340	1	0.3
Open Pond No. 8	690	18	2.6
Cages in Pond No. 8	331	1	0.3
Open Pond No. 12	1,000	34	3.4
Cages in Pond No. 12	320	1	0.3
Open Pond No. 10	1,000	2	0.2
Cages in Pond No. 10	320	3	0.9
Open Pond No. 13	2,500	8	0.3
Cages in Pond No. 13	410	4	1.0%

\**Ictalurus punctatus*

\*\*Ponds 5 &amp; 14 (Auburn Alabama Catfish Strain), Ponds 8 &amp; 12 (Norris Mississippi Catfish Strain), Ponds 10 &amp; 13 (James River Virginia Catfish Strain)

of strain differences or aquacultural methods on the levels of total lipids in them. Thus, the objective of this study was to determine if different strains of channel catfish or the aquacultural techniques used for raising them, were significant determinants of muscle and liver fat levels. Selection of the strains for the study was based upon their availability at the Virginia State University's Randolph Farm, while the pond and cage methods were selected, not only because they were available at our facility, but also, because they were the two most commonly used methods in channel catfish production today.

#### MATERIALS AND METHODS

##### Fish Culture:

The catfish strains used were Norris Mississippi (MS), Auburn Alabama (AL), James River Virginia (VA) and VA recessive albino. All fish were approximately one year old and over-wintered in 1987 at Randolph Farm, Virginia State University, Petersburg, Virginia. Fish ranged in standard length from 7.5 cm to 22.5 cm and in weight from 20 g to 45 g. They had been kept throughout winter on a maintenance commercial diet and fed no more than three times a week at regular intervals.

Individual strains of catfish were raised in two 0.051 ha ponds and four m<sup>3</sup> cylindrical and commercially constructed cages from Inqua Corporation, Dobbs Ferry, New York. Each pond was supplied with two cages, which were floated from

the deep end of the ponds. Catfish fingerlings were restocked into cages at approximately 250 fish/m<sup>3</sup> of water.

Fish were continued on a scientifically formulated and balanced ration extruded into a floating water stable nugget from Ziegler Brothers, Inc., Gardners, PA., and fed twice daily at 5% of their estimated body weight. Feed rates were adjusted every 14 days based upon a 1.5:1 feed conversion ratio as described by Robinson and Newton (1982). The feeding schedule lasted for 90 days from July 10, 1988, until October 9, 1988, when the fish were harvested.

Ten fish were randomly selected from each pond and cage and their liver and muscle tissue samples analyzed for total lipids. To minimize oxidation, tissue samples were frozen under a nitrogen atmosphere in sealed sample bottles, then stored in a freezer below -20°C until they were analyzed. Although the albino and the normal fish from the VA strain were raised together within the same ponds and cages, each category was analyzed separately for total lipids.

#### Water Quality:

Temperature and dissolved oxygen readings of the ponds were taken twice daily at sunrise and sunset using a Yellow Springs Instruments oxygen meter while the pH and hardness were recorded at regular intervals twice a week using a Hach Fish Farming water analysis kit.

#### Analysis of Total Lipids:

Total lipids of tissue samples were extracted following the dry column method of Maxwell *et al.* (1980). Each 1-3 g sample of the frozen or fresh liver or muscle tissue was homogenized in a Vitis blender (Model 45) for 2 minutes with a 25 ml mixture of dichloromethane and methanol (9:1, v/v). The homogenate mixture was transferred to a 19 mm x 400 mm 250 ml glass column packed with 2 g of Ca(HPO<sub>4</sub>)<sub>2</sub>/Celite 545 (1:9, w/w) and topped with 4 g of anhydrous sodium sulfate. The column was eluted with 250 ml in total of dichloromethane/methanol (9:1, v/v). The extracted lipid was collected in a tared flask. The solvent was removed under reduced pressure and the total lipids determined gravimetrically. Data were expressed as weight-percentages for the ten samples extracted. They were analyzed statistically as a completely randomized split plot design with two replications as described by Little and Hills (1978). A t-test from Statistical Analysis System was used to evaluate the effects of the fish culture methods on the means of the liver and muscle fat values.

## RESULTS AND DISCUSSIONS

Water quality was good throughout the study which allowed for an efficient operation of the catfish culture as recommended by Piper *et al.* 1982 and Boyd, 1979. Temperatures ranged between  $16.4 \pm 0.15^{\circ}\text{C}$  and  $33.45 \pm 0.91^{\circ}\text{C}$ . Oxygen levels fluctuated between  $3.89 \pm 0.7 \text{ mg/l}$  and  $20 \text{ mg/l}$ , while the pH varied between 6.7 and 8.3. Mortality was not significant (Table 1).

There were no significant differences [ $P > 0.05$ ] in muscle or liver fat levels among the different strains of catfish raised in ponds or cages (Table 2). Similarly, no significant catfish strain by method interactions in fat levels were found in this study. However, for each strain, livers had significantly greater fat contents than muscles regardless of the aquacultural method (open pond  $P < 0.0002$ ; cage  $P < 0.0075$ ).



TABLE 2. Lipid composition\* of the livers and muscle tissues of selected geographical strains of channel catfish reared in ponds and cages at Randolph Farm, Virginia State University Petersburg, Virginia

STRAINS	POND		CAGE	
	Livers	Muscles	Livers	Muscles
AL	2.68	0.88	2.93	1.52
MS	2.56	1.03	2.85	1.31
VA/albino	3.16	0.98	2.34	0.71
VA/normal	2.19	1.03	1.88	1.53
Mean	2.65	0.98	2.25	1.27

\*Composition in Weight Percentages

Since the three geographical strains, including the VA albino catfish strain, were raised under similar conditions and showed comparable levels of lipids, this study indicates that geographical origin and the albino recessive genotype of the VA strain are not contributing factors to the ability of the catfish to fatten on a normal commercial catfish chow. Wild fish seldom show signs of nutritional diseases (Lovell, 1979). Excessive dietary lipid may result in nutritional diseases like fatty liver or cause large fat deposition in the muscle and viscera, thus producing off-flavors, spoiling the quality of the fish and reducing its dress-out weight percentage (Yamada, 1986). However, levels of fat in our farm-raised channel catfish remained below the literature averages of 3.6% of a fillet cut. This is good from both the human nutrition and commercial grower standpoints. This study leads us to hypothesize that cultured channel catfish do not have more fat reserves in them than their wild counterparts nor is one geographical strain of catfish more suitable than others for commercial purposes.

#### ACKNOWLEDGEMENTS

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#### LITERATURE CITED

- Al-Ahmad, T. A. 1983. Relative Effects of Feed Consumption and Feed Efficiency on Growth of Catfish from Different Genetic Backgrounds. Doctoral Dissertation. 59 pages. Auburn Univ., AL.
- Bice, T. O. 1981. Spawning Success, Fecundity, Hatchability, and Fry Survival in Strain and Reciprocal Pairings of Marion and Kansas Channel Catfish. Master's Thesis. 17 pages. Auburn Univ., AL.
- Boyd, G. E., 1979. Water Quality in Warmwater Fish Ponds. 30 pages. Auburn University Agriculture Experiment Station, Auburn University, Auburn, Alabama, U.S.A.
- Broussard, M. C., Jr. and Stickney, R. R. 1981. Evaluation of Reproductive Characters for Four Strains of Channel Catfish. Trans. Am. Fish. Soc. 110, 502-506.



- Broussard, M. C., Jr. and Stickney, R. R. 1984. Growth of Four Strains of Channel Catfish in Communal Ponds. Proc. Ann. Conf. Southeast. Assoc. Fish Wild. Agen. 35 (1981), 541-546.
- Burnside, M.C., Avault, J. W., Jr., and Perry, W. G., Jr. 1975. Comparison of a Wild and a Domestic Strain of Channel Catfish Grown in Brackish Water. Prog. Fish-Cult. 37, 52-54.
- Chappell, J. A. 1979. An Evaluation of Twelve Genetic Groups of Catfish for Suitability in Commercial Production. Doctoral Dissertation. 74 pages. Auburn University, AL.
- Dunham, R. A. and Smitherman, R. O. 1981. Growth in Response to Winter Feeding of Blue, Channel, White and Hybrid Catfishes. Prog. Fish-Cult. 43, 63-66.
- Exler, J., J. E. Kinsella, and B. K. Watt (1975). Lipids and Fatty Acids of Important Finfish: New Data for Nutrient Tables. Journal of the American oil Chemists' Society. 52:154-159.
- FAO (1977). Dietary Fats and Oils in Human Nutrition: A joint FAO/WHO Report. 94 pages. FAO, Rome.
- Green, O. L., Smitherman, R. O., and Pardue, G. B. 1979. Comparisons of Growth and Survival of Channel Catfish, *Ictalurus punctatus*, from Distinct Populations. In: Advances in Aquaculture, T. V. R. Pillay and W. A. Dill (Editors). Fishing News Books, Farnham, Surrey, England.
- Horn, J. L., 1981. Spawning Success, Fecundity and Egg Size in Seven Genetic Groups of Four-year-old Channel Catfish, *Ictalurus punctatus* (Rafinesque). Master's Thesis. 22 pages. Auburn Univ., AL.
- Jauncy, K. (1982). The Effects of Varying Dietary Protein Level on the Growth, Food Conversion, Protein Utilization and Body Composition of Juvenile Tilapias (*Sarotherodon mossambicus*). Aquaculture 27:43-54.
- Lee, D. J. and G. B. Putnam (1973). The Response of Rainbow Trout to Varying Protein/Energy Ratios in a Test Diet. J. Nutr. 103:916-922.
- Little, T. M. and F. J. Hills (1978). Agricultural Experimentation: Design and Analysis. 350 pages. John Wiley and Sons, N.Y.
- Lovell, R. T. 1979. Fish Culture in the United States. Science. 206:1368-1372.
- Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Fowler, and J. R. Leonard, (1982). Fish Hatchery Management. 517 pages. United States Department of the Interior Fish and Wildlife Service, Washington, D.C.
- Maxwell, R. J., W. N. Marmer, M. P. Zubillage, and G. A. Dalickas (1980). Determination of Total Fat in Meat and Meat Products by A Rapid, Dry Column Method. JAOAC. 63:600-603.
- Plumb, J. A., Green, O. L., Smitherman, R. O., and Pardue, G. B. 1975. Channel Catfish Virus Experiments with Different Strains of Channel Catfish. Trans. Am. Fish. Soc. 104, 140-143.
- Reinitz, G. L., L. E. Orme, C. A. Lemm, and F. N. Hitzel (1978). Influence of Varying Lipid Concentrations with Two Protein Concentrations in Diets for Rainbow Trout (*Salmo gairdneri*). Trans. Am. Fish Soc. 107:751-754, (1978).
- Ringrose, R. C. (1971). Calorie-to-protein Ratio for Brook Trout (*Salvelinus fontinalis*). J. Fish. Res. Bd. Can. 28:1113-1117.

- Robinson, W. R. and S. H. Newton (1982). Effect of Stocking Density on Channel Catfish Growth, Survival and Food Conversion Efficiency in Cages. Arkansas Academy of Science Proceedings, XXXVI : 101-102.
- Shrestha, S. B. 1977. The Parasites of Different Strains and Species of Catfishes (*Ictalurus* spp.) Master's Thesis. 26 pages. Auburn Univ., AL.
- Smitherman, R. O., Green, O. L., and Pardue, G. B. 1974. Genetics Experiments with Channel catfish. Catfish Farmer and World Aquaculture News 6(3), 43-44.
- Watanabe, T., (1982). Lipid Nutrition in Fish. Comp. Biochem. Physiol. 73B:3-15.
- Yamada, R. 1986. Pond Production Systems: Feeds and Feeding Practices in Warmwater Fish Ponds, pp. 111-139. In: J. E. Lannan, R. O. Smitherman and G. Tehobanoglous (eds.), Principles and Practices of Pond Aquaculture. 251 pages. Oregon State University Press, Corvallis, Oregon.
- Youngblood, P. N., 1980. Growth and Feed conversion of Six genetic Groups of Adult Channel Catfish Selected as Broodstock. Master's Thesis. 35 pages. Auburn Univ., AL.

## A Range Extension of the Marsh Rabbit, *Sylvilagus palustris*, from Southeastern Virginia

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On 28 November 1987, a female marsh rabbit (*Sylvilagus palustris*) was taken by a hunter in the vicinity of Fountain Creek, a small tributary of the Meherrin River in extreme southeastern Greensville County. This specimen represents the first known record of a marsh rabbit from Greensville County as well as a range extension of approximately 80 km west of its known distribution in Virginia.

Measurements are as follows: total length, 410 mm; length of tail, 42 mm; length of hind foot, 93 mm; length of ear, 62 mm; and weight, 1625 g. The specimen was preserved as a study skin and was deposited in the vertebrate teaching collection at Old Dominion University (ODU 623).

The marsh rabbit can be distinguished from our more common cottontail rabbit (*Sylvilagus floridanus*) by having a dark rich brown pelage, a short tail that is grayish underneath instead of the conspicuously white underside of the cottontail, short, slender legs, and short, broad ears. The marsh rabbit is aptly named, as it is found only in relatively undisturbed bottomland forests and marshes, and readily takes to water when pursued. When swimming or hiding in the water, only the top of its head and nose are visible (Bailey, 1946).

Prior to this specimen, the distribution of the marsh rabbit in Virginia was known from only a few specimens collected during the late 1890's from Virginia Beach, Chesapeake, and the Dismal Swamp in Suffolk. (Handley and Patton, 1947). Payne (1975) trapped 37 marsh rabbits at Hog Island State Waterfowl Refuge along the James River in Surry County, approximately 30 km north of the Dismal Swamp. However, since that time, no additional marsh rabbits have been observed or collected at that locality (W. C. Abernathy, D. Schwab, VDGIF, pers. comm.). Whether it still exists in the vicinity of Hog Island is unknown.

Since the marsh rabbit is restricted to relatively undisturbed wetlands, an environment that is rapidly disappearing throughout southeastern Virginia, as well as the general lack of information regarding its distribution and life history, the status of this animal in Virginia is uncertain. Therefore, further research regarding the status and distribution of the marsh rabbit in Virginia is urgently needed.

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### LITERATURE CITED

- Bailey, J. W. 1946. The mammals of Virginia. Publ. by the author. Williams Printing Co., Richmond. 416 pp.
- Handley, C. O., Jr., and C. P. Patton. 1947. Wild mammals of Virginia. Va. Comm. Game and Inland Fisheries, Richmond. 220 pp.
- Payne, N. F. 1975. Range extension of the marsh rabbit in Virginia. Chesapeake Sci. 16:77-78.



## AWARDS PRESENTED DURING THE VIRGINIA JUNIOR ACADEMY OF SCIENCE MEETING

### AGRICULTURAL AND ANIMAL SCIENCE

Honorable Mention:	Aimee M. Bowen Anne M. Harwell J. Stacy Johnson	Monacan High School E. C. Glass High School Thomas Jefferson High School for Science and Technology
Third place:	Lisa K. Roschke	H. B. Woodlawn
Second place:	Kristen W. Smeltzer	Midlothian High School
First place:	Cheryl Hubbard	Norfolk Academy

### ANIMAL BEHAVIOR (ETHOLOGY)

Honorable Mention:	Eric D. Hermes Hassan I. Huq Bradley C. Zeigler	Hampton High School Monacan High School Patrick Henry High School
Third Place:	Melissa A. Crouch	Lloyd C. Bird High School
Second Place:	Julia P. Trice	Richmond Community High School
First Place:	Chad A. Hudson	Meadowbrook High School

### BOTANY 'A'

Honorable Mention:	William G. Broaddus, Jr. Kym L. Edwards Amy C. Harmatuk	The Collegiate Schools Yorktown High School Hines Middle School
Third Place:	Don F. August	Patrick Henry High School
Second Place:	Barry T. Davis	Monacan High School
First Place:	Kimberly P. Bryant	Patrick Henry High School

### BOTANY 'B'

Honorable Mention:	Ajay Jain Nora W. Petersen Matthew B. Retzer	Monacan High School Swanson Intermediate School Williamsburg Intermediate School
Third Place:	Mohamed Y. Rakha	Wakefield High School
Second Place:	Melissa K. O'Brien	Patrick Henry High School
First Place:	Zion W. Lo	Central Virginia Magnet School

**BOTANY 'C'**

Honorable Mention:	Timothy S. Shephard, Jr.	Roanoke Valley Governor's School for Science and Technology
	Deaette M. Smith	Armstrong High School
	Amy L. Wright	Patrick Henry High School
Third Place:	Sean R. Stewart	Meadowbrook High School
Second Place:	Brian T. Whitaker	Patrick Henry High School
First Place:	Piero U. Simoni	Wakefield High School

**CHEMISTRY 'A'**

Honorable Mention:	Brian K. Butcher	Menchville High School
	Henry E. Chung	Thomas Jefferson High School for Science and Technology
	Ochida Iep	Thomas Jefferson High School for Science and Technology
Third Place:	Lori A. Madill	Thomas Jefferson High School for Science and Technology
Second Place:	Michael P. Keith	Thomas Jefferson High School for Science and Technology
First Place:	Paul W. Carter	Thomas Jefferson High School for Science and Technology

**CHEMISTRY 'B'**

Honorable Mention:	Melissa G. Parker	Patrick Henry High School
	Michael P. Richardson	Heritage High School
	Mina K. Yu	Thomas Jefferson High School for Science and Technology
Third Place:	Stephanie D. Powell	Lee-Davis High School
Second Place:	Kurt M. Snyder	Thomas Jefferson High School for Science and Technology
First Place:	Colin Prepiscius	Thomas Jefferson High School for Science and Technology

**COMPUTER SCIENCE**

Honorable Mention:	Daria Farassat	Menchville High School
Third Place:	Timothy I. Mattox	Central Virginia Magnet School
Second Place:	Thuan Thai	Wakefield High School
First Place:	Tony F. Deboeck	Bishop Denis J. O'Connell High School

## CONSUMER SCIENCE 'A'

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The Population Biologists of the Northeastern and the Southeastern Ecological Genetics Group will hold a joint meeting at the Continuing Education Center, Virginia Polytechnic Institute and State University, Blacksburg, VA, May 17-19, 1990. Plenary speakers are May Berenbaum (University of Illinois), David Tilman (University of Minnesota), and Mary Jane West-Eberhard (University of Costa Rica); James Karr (Virginia Tech) will deliver the post-banquet address. Undergraduate students, especially those from the area's smaller colleges, who are considering graduate study in biology are invited to attend and meet the professors and their students from many universities who will be presenting papers at this meeting. For further information, contact Dr. Bruce Wallace, Department of Biology, V.P.I. and S.U., Blacksburg, VA 24061-0406. Tel: (703) 231-8943.



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## Plankton in the James River Estuary, Virginia. V. Phytoplankton Composition of the Nansemond River

Cindy E. Shomers and Harold G. Marshall

Department of Biological Sciences  
Old Dominion University  
Norfolk, Virginia 23529

### ABSTRACT

Two phytoplankton size groups characterized the Nansemond River. One was a pico-nanoplankton component composed of cyanobacteria, chlorophytes and microflagellates. An assemblage of larger cells composed the second group and was dominated by diatoms, dinoflagellates, cryptomonads and euglenoids. Both categories followed a bimodal pattern of abundance with spring and fall maxima. The dominant species were common for the region and similar to those of the lower James River drainage basin.

### INTRODUCTION

The Nansemond River is part of the James River tidal watershed in southeastern Virginia and is in close proximity to the shipping and metropolitan complex of Norfolk, Virginia. Although there is only modest development along its shoreline, the drainage basin of the Nansemond River is a likely location for future development of industry or residential communities. At this time a study of the river's phytoplankton composition is considered appropriate for establishing a biological data base for future comparisons to possible changes in water quality resulting from such activities. The objectives of this study are: 1) To characterize the phytoplankton in the Nansemond River, and 2) Compare these populations to phytoplankton from other locations in the lower James River drainage basin.

Past studies of phytoplankton in the lower James River indicate a rich algal flora with seasonal production peaks dominated by diatoms, cryptomonads, and cyanobacteria (Birdsong *et al.*, 1988; Filardo and Dunstan, 1985; Shomers and Marshall, 1987). The phytoplankton in nearby Lafayette and Elizabeth Rivers were investigated by Marshall (1967a, 1967b, 1968), O'Reilly (1987) and Purcell (1975). These tidal rivers have a phytoplankton composition similar to the lower James River and Chesapeake Bay region (Marshall and Lacouture, 1986). In an early study, Brehmer *et al.* (1967) monitored several water quality parameters that included phytoplankton and chlorophyll *a* for the Nansemond River. They identified *Peridinium* (*Scrippsiella*) *trochoideum* as a summer dominant, with *Thalassiosira nordenskioldii* and *Peridinium triquetrum* (*Heterocapsa triquetra*) having high winter concentrations.

### METHODS

Two stations were established in the Nansemond River (Figure 1.) Monthly surface (< 1 m) water samples were taken with a one liter Kemmerer water bottle from November 1984 to October 1985. Replicate sub-samples of 250 ml each were taken and preserved with Lugols solution. The samples were processed by a

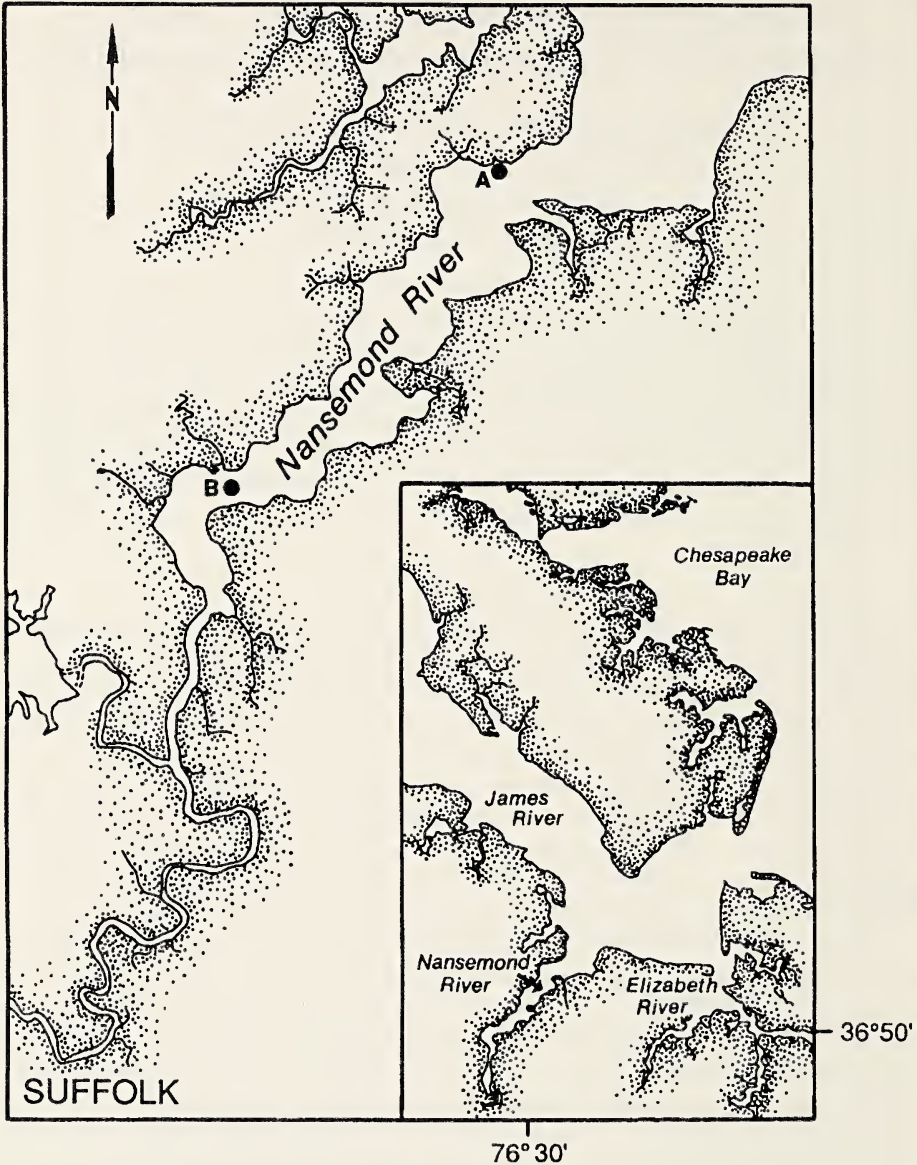


FIGURE 1. Location of stations A and B in the Nansemond River.

siphoning and settling procedure to obtain a 30-40 ml concentrate for subsequent analysis (Shomers, 1988). The concentrates were analyzed with an inverted plankton microscope, using a random field, minimum count (200 cells) plan at 312x and 500x for the nano- and picoplankton, with the entire concentrate scanned at



TABLE 1. Results of a paired T-test on surface salinity and temperature values from stations A and B from November 1984 to October 1985.

	STA	MEAN	STD.DEV.	T	DF	P >  T
Temperature	A	19.06	7.94	0.2711	21.9	0.7888
	B	19.92	7.57			
Salinity	A	15.62	1.84	-1.1187	21.7	0.2755
	B	14.73	2.05			

125x for net phytoplankton. This procedure provided an 85% accuracy estimate for the counts (Venrick, 1978). Cells were identified to species whenever possible, with species concentrations converted to cell volumes as described by Kovala and Larrance (1966). In addition, nitrogen and phosphate analyses were included at each station in August and October, following the salicylate/nitroprusside and ascorbic acid methods (EPA, 1979).

A log transform ( $\log_{10}(x + 1)$ ) approach was utilized to normalize cell distributions (Cassie, 1963) which were analyzed by two-way analyses of variances and Duncan range tests to determine effects of station and seasonality on cell concentrations of the major phytoplankton groups. In instances where interactions were found between station and seasonality, one-way analyses of variance, coupled with the Duncan range test were performed. The averages of the replicate samples were utilized to describe seasonal patterns and total concentrations. For descriptive purposes monthly samples were divided into the traditional four seasons. One-way analyses of variances were conducted on water temperature and salinity to determine if significant differences occurred by sampling date, with paired t-tests used to determine if temperatures and salinities were significantly different between stations. In addition, an average link cluster analysis was performed on taxa contributing at least 0.01% of the total average seasonal concentrations to determine any similarities in species occurrence and their concentrations (SAS Institute, Inc., 1985).

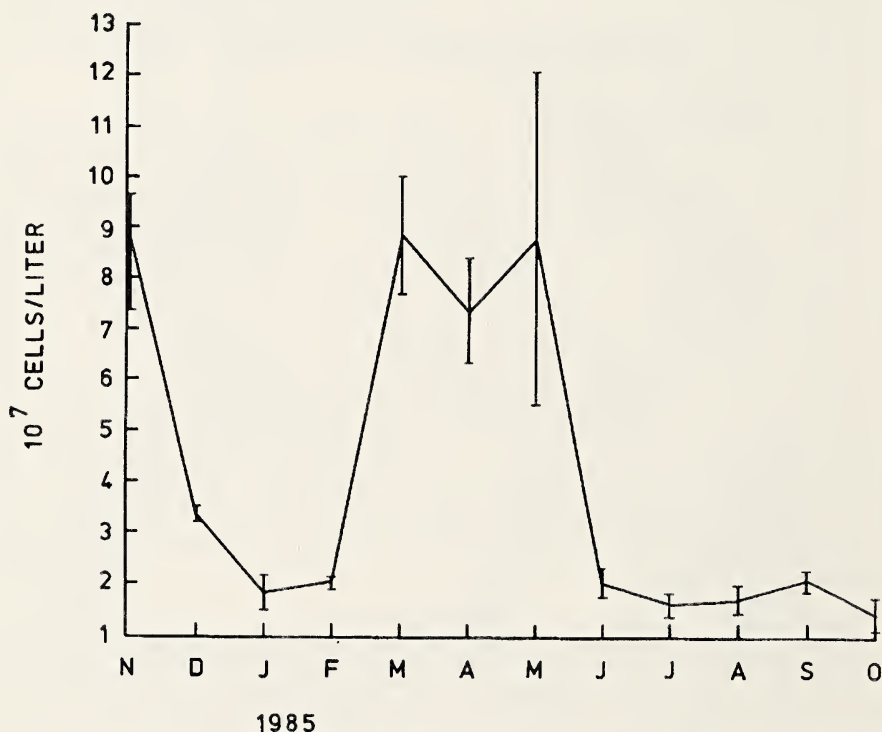
## RESULTS

Average surface water temperatures ranged from 4.4°C (February) to 29.2°C (September). The salinities declined from Fall to an early Spring (March) low of 12‰ before rising in late Spring to an 18.4‰ high in Summer (July). A paired t-test found temperature and salinity values between the two stations not significant ( $p = 0.05$ , Table 1). However, significant differences were found in both temperature and salinity values with sampling data (Table 2). The nutrient analysis in August and October indicated the TKN and  $PO_4$  concentrations for both stations were similar. TKN values were between 0.61 and 0.69 mg/l, with  $PO_4$  levels 0.127 to 0.163 mg/l.

There were 99 phytoplankters identified in the Nansemond River during the study period (Shomers, 1988). These included: Bacillariophyceae (67), Chlorophyceae (6), Chrysophyceae (3), Dinophyceae (17), Euglenophyceae (4),

TABLE 2. Results of one-way ANOVAs of surface water temperature (A) and salinity (B) values by sampling date.

	Source	DF	SS	MS	F	F PROB	R SQ
A.	Date	11	1,303.24	118.48	58.98	0.0001	0.98
	Error	12	24.10	2.01			
	Total	23	1,327.35				
B.	Date	11	77.27	7.02	7.88	0.0006	0.88
	Error	12	10.70	0.89			
	Total	23	87.97				

FIGURE 2. Mean pico-nanoplankton concentrations (cells 1.5 - 10  $\mu$ m) in the Nansemond River from November 1985 to October 1986.

Haptophyceae (1), Prasinophyceae (1) and several unidentified pico-nanoplankters. This last component was composed mainly of cyanobacteria, chlorophycean and microflagellate cells < 10  $\mu$ m in diameter. The lower size limit for this group was 1.5  $\mu$ m, with the exception of several colonial species that were smaller in size, but able to be distinguished from heterotrophic cells (e.g. *Merismopedia tenuissima*). Not included in this study were the other autotrophic cells less than 1.5  $\mu$ m in size.

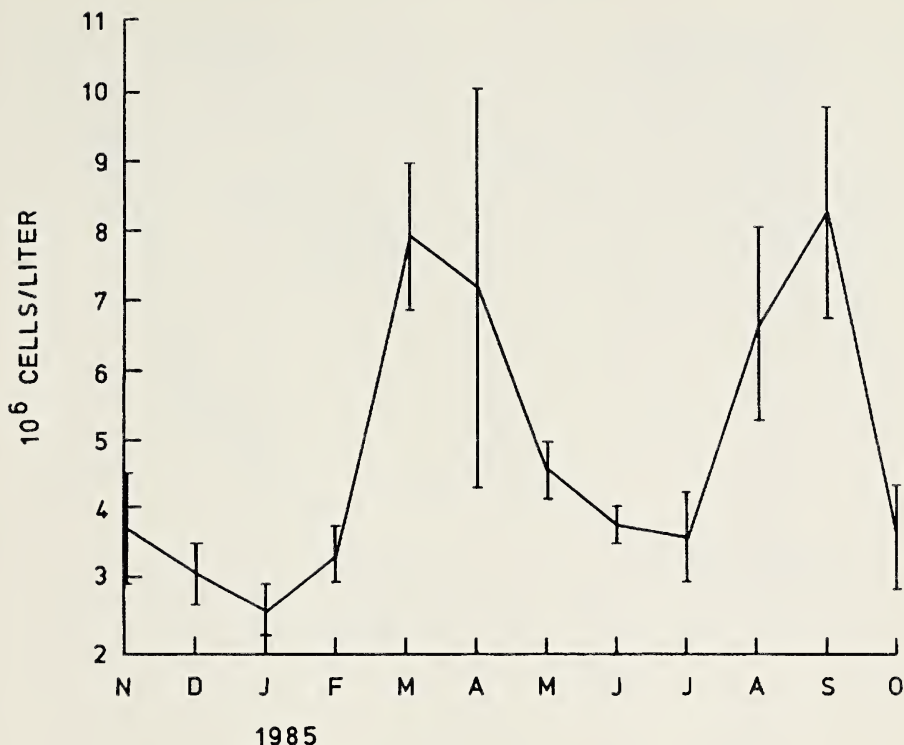


FIGURE 3. Mean phytoplankton concentrations excluding the pico-nanoplankton component for the Nansmond River from November 1985 to October 1986.

These phytoplankton groups were tested with two-way analyses of variance to determine if significant differences occurred between mean concentrations, station location, and sampling date (Shomers, 1988). Each were found to have significant differences in concentrations with sampling date. The cryptophytes and euglenophytes also had significant differences in concentrations with the stations ( $p < 0.001$  and  $p < 0.05$ , respectively). The diatoms had significant interaction ( $p < 0.01$ ) between times of collection and station for December 1984, February 1985 and September 1985.

The combined pico-nanoplankton ( $< 10 \mu\text{m}$ ) concentrations decreased from a Fall maximum to a Winter low before increasing rapidly to produce a major Spring pulse of  $4.1 \times 10^7$  cells/l, (Figure 2). Declining numbers followed in Summer with a modest development in Fall 1985. This was predominantly a unimodal pattern for 1985 due to high summer concentrations of picoplankton which were ubiquitous throughout the study. The other phytoplankters produced a bimodal pattern of annual abundance. These cells had a winter low, increasing to a Spring peak followed by a Summer and a Fall bloom before decreasing again into Winter (Figure 3). In contrast to seasonal observations, O'Reilly (1987) conducted a short-term study in the Elizabeth River and found a tidal and temporal interaction with chlorophyll *a*. He noted a significant relationship between slack water and chlorophyll *a* distribution, with higher values during slack before flood, or low water periods.



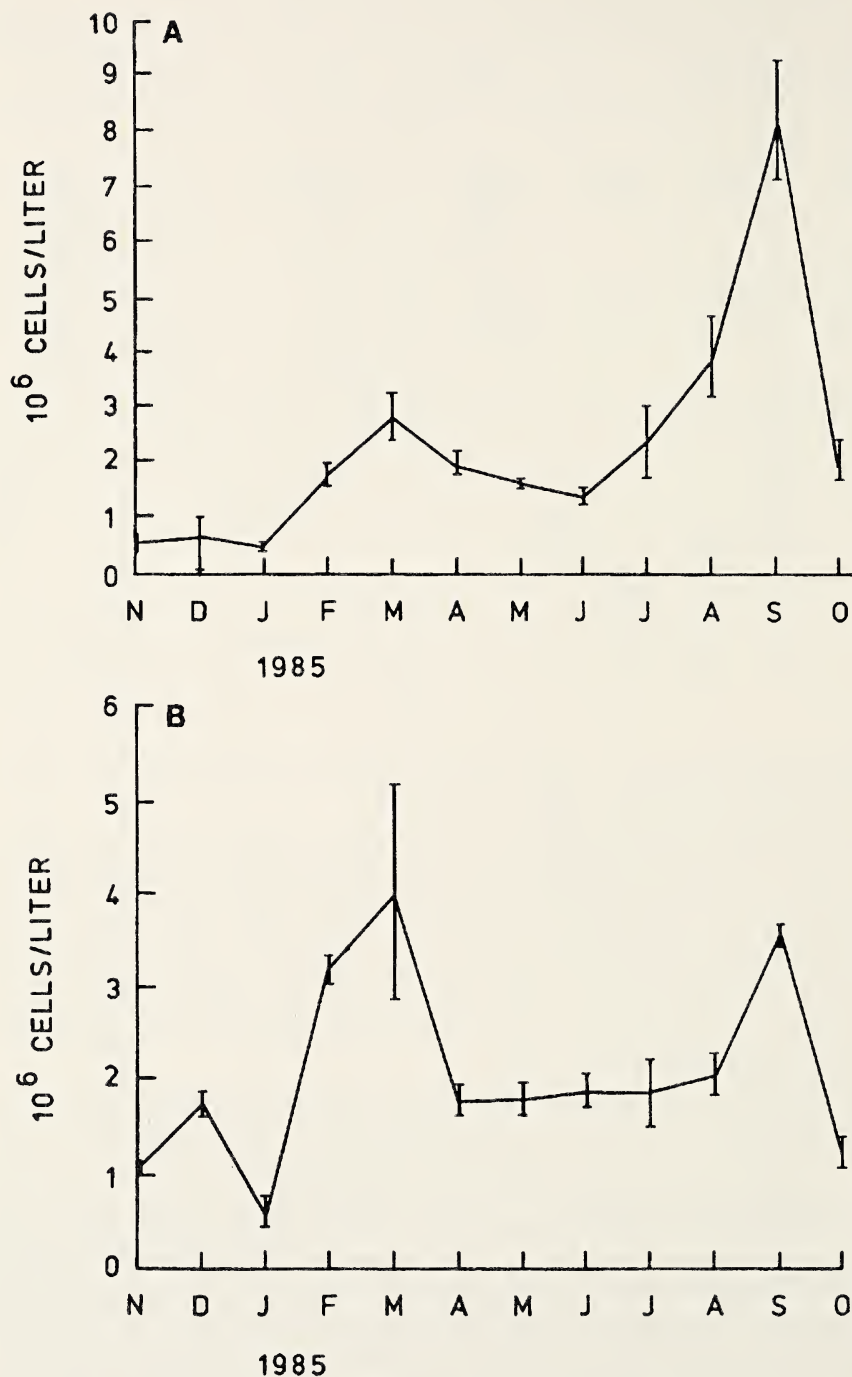
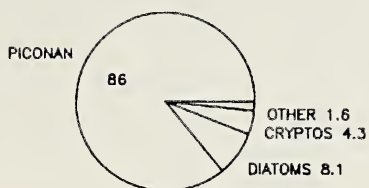


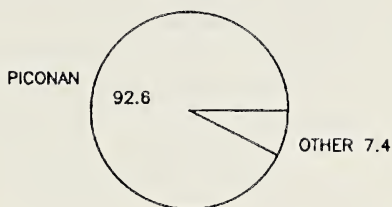
FIGURE 4. Diatom concentrations at Stations A and B in the Nansemond River from November 1985 to October 1986.

**a.**

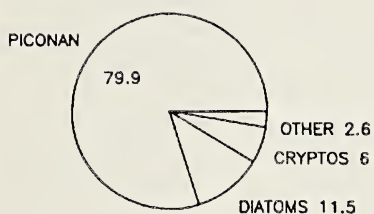
WINTER



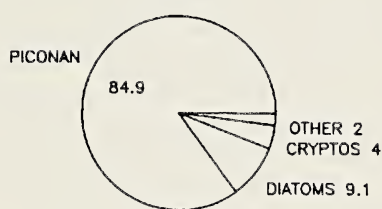
SPRING



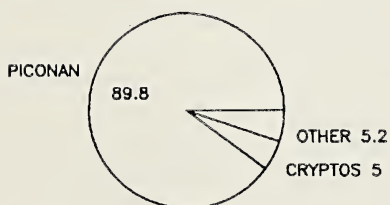
SUMMER



FALL

**b.**

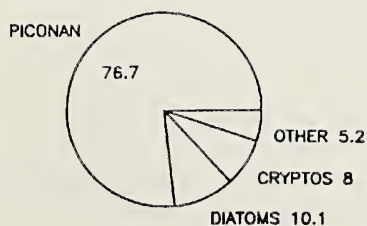
WINTER



SPRING



SUMMER



FALL

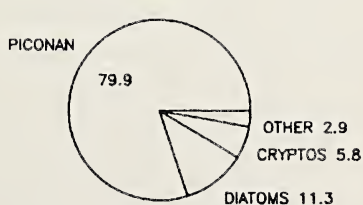


Figure 5. Seasonal concentration relationships of the major phytoplankton categories at Stations A and B in the Nansemond River for the study period.

## SEASONAL PATTERNS OF MAJOR PHYTOPLANKTON CATEGORIES

The diatoms were one of the abundant phytoplankton groups in the river. The major algal species included *Skeletonema costatum*, *Cylindrotheca closterium*, and *Nitzschia pungens*. Cell concentrations were lowest in Winter, with January concentrations for the upriver and downriver stations containing  $4.5 \times 10^5$  and  $5.8 \times 10^5$  cells/l respectively (Figure 4). The more abundant Winter diatoms were *Thalassiosira nordenskioeldii*, *T. rotula*, *Asterionella glacialis*, *Achnanthes* spp., *Chaetoceros* spp., *Melosira moniliformis* and *M. nummuloides*.

Following the Winter low, diatom concentrations had a modest rise in Spring that coincided with rising water temperature. Spring dominants included *Asterionella glacialis*, *Melosira granulata*, *Thalassiosira nordenskioeldii*, *T. rotula*, *Rhizosolenia delicatula*, *Achnanthes* spp., *Pleurosigma* spp., *Fragilaria* spp., and *Paralia sulcata*. The decline of diatom concentrations first began downstream and continued into Summer when *Gyrosigma fasciola*, *Cyclotella caspia*, *Gyrosigma* spp., and *Pleurosigma* spp. were more abundant. A Fall bloom occurred in September 1985 with concentrations significantly higher upriver ( $p < 0.01$ ) reaching  $8.3 \times 10^6$  cells/l. This period had the greatest species diversity and included *Cyclotella meneghiniana*, *Cyclotella caspia*, *Cylotella* spp., *Thalassiosira* spp., *Achnanthes* spp., *Chaetoceros constrictus*, *Fragilaria* spp., *Bacillaria paxillifer* and *Thalassiosira eccentrica*. A decline in abundance also accompanied decreasing temperatures. However, at this time concentrations were significantly higher ( $p < 0.01$ ) in the lower Nansemond, with concentrations reaching  $4.0 \times 10^6$  cells/l.

The mean seasonal concentration relationships for the major categories at both stations are given in Figure 5. The cryptomonads were the most abundant phytoflagellates in the Nansemond, being generally more numerous upriver (Shomers, 1988). However, their cell concentrations were variable throughout the year, with lowest numbers in late Winter and increased abundance during Spring and late Fall. This group was represented throughout the year by several *Cryptomonas* spp. Among the Dinophyceae the Fall and Winter concentrations were low and mainly represented by *Katodinium rotundatum*, several *Gymnodinium* spp., *Heterocapsa trigueta* and *Prorocentrum minimum*. Concentrations decreased in mid-Spring to a Summer low when there was a variety of dinoflagellates present (*Gymnodinium* spp., *Amphidinium* spp., *Katodinium rotundatum*, and *Protoperidinium brevipes*). A second pulse occurred in early Fall and included *Gymnodinium* spp., *Heterocapsa trigueta*, *Prorocentrum minimum*, *Ceratium lineatum* and *Prorocentrum triestinum*. The seasonal maxima and minima for the dinoflagellates appeared to follow an inverse relationship to salinity.

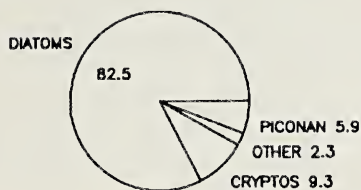
The most abundant euglenoids were *Eutreptia viridis* and *Eutreptia lanowii*. Their cell concentrations were low in Fall (1984) and Winter, but the group was noted year round, reaching a Summer peak of  $2.7 \times 10^5$  cells/l. Other phytoflagellates included low concentrations and diversity of haptophytes, prasinophytes and chrysophytes. The Haptophyceae (coccolithophores) were most common in late Winter and early Spring, with the prasinophytes more abundant during Spring. The chrysophytes include the silicoflagellates which were abundant in Spring and July, and *Calycomonas wulfii* in Fall.

The larger cyanobacteria not included in the pico-nanoplankton category had concentrations decreasing from a Fall (1984) peak to a Winter low, followed by a

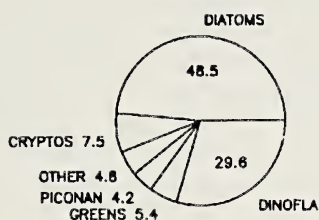


**a.**

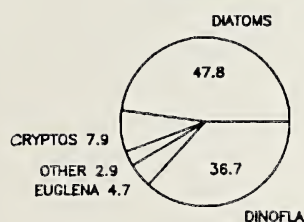
WINTER



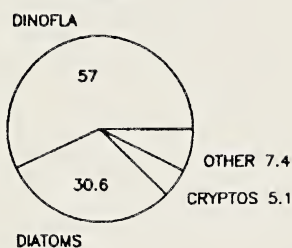
SPRING



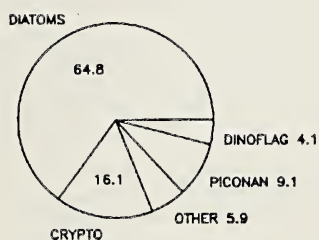
SUMMER



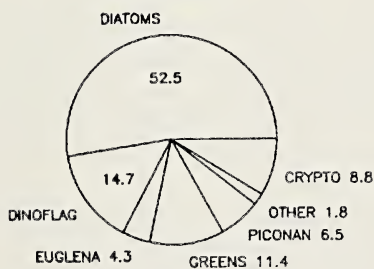
FALL

**b.**

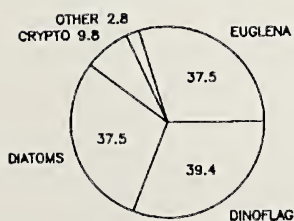
WINTER



SPRING



SUMMER



FALL

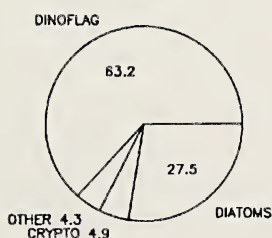


FIGURE 6. Seasonal cell volume relationships of the major phytoplankton categories at Stations A and B in the Nansemond River for the study period.

Spring pulse. The more common cyanobacteria included *Dactylococcopsis raphidioides*, *Merismopedia* spp., and *Nostoc* spp. in Fall plus *Agmenellum* sp. in Spring. The Chlorophyceae were generally low in abundance throughout the year, but their highest concentrations occurred in late Fall (1984), averaging  $4.0 \times 10^5$  cells/l and in mid-Spring ( $1.7 \times 10^4$  cells/l). Seasonal lows were in Winter ( $1.7 \times 10^4$  cells/l) and from late Summer to early Fall 1985 (43 cells/l). However, a Duncan range test indicated average concentrations were not significantly different from fall 1984 through summer 1985. Major species in fall (1984) included *Chlorella* spp. and *Staurostrum* spp., with *Ankistrodesmus falcatus* in Spring.

The mean seasonal contributions of different taxonomic groups to the total cell volume (biomass) was similar for both stations and are given in Figure 6. From Winter through Spring, between 52.5 to 64.8% of the phytoplankton biovolume came from diatoms. Dinoflagellates represented the major biomass in both Summer (39.4%) and Fall (63.2%). The results of a cluster analysis of species composing 0.1% or greater of the average seasonal concentrations resulted in three primary groups (Shomers, 1988). Group I contains species or categories abundant throughout the year (e.g. *Skeletonema costatum*) and Group II is composed of species that have high abundances with a lower frequency of occurrence (e.g. *Cyclotella meneghiniana*), or a high frequency of occurrence and intermediate abundances (e.g. *Chaetoceros* spp.). Group III is composed of forms only common in Winter and Spring. These included *Katodinium rotundatum*, *Asterionella glacialis* and several unidentified chrysophyceans and coccolithophorids.

## DISCUSSION

The majority of phytoplankton in the Nansemond River were neritic species similar to those observed throughout the lower Chesapeake Bay and in rivers that are part of the lower James River drainage system (Marshall, 1967a, 1967b, 1967c, 1968; Marshall and Lacouture, 1986; Mulford, 1972). North temperate diatoms ubiquitous throughout the year included high concentrations of *Nitzschia pungens* and *Skeletonema costatum*, with *Rhizosolenia delicatula*, *R. setigera* and *Thalassionema nitzschoides* common. Abundant south temperate species included *Asterionella glacialis*, *Ditylum brightwellii* and *Eucampia zodiacus*. The representative brackish and littoral species were *Cylindrotheca closterium*, *Paralia sulcata*, and *Cyclotella caspia*.

The most abundant diatom was *S. costatum*, with seasonal mean concentrations ranging from 1.8 to  $57.1 \times 10^4$  cells/l for Spring and Summer respectively. *S. costatum* was one of the 36 species Mulford (1972) listed as accounting for the majority of planktonic biomass in the Chesapeake Bay. Another characteristic group in the Nansemond River was the cryptomonads. Generally these were more abundant upriver and had average seasonal concentrations of  $181.5 \times 10^4$  cells/l. The absence or low concentrations of this group in earlier studies may be due to preservation techniques that destroyed these cells (Marshall, 1984; Marshall and Lacouture, 1986). However, Patten *et al.* (1963) and subsequent reports have emphasized the importance of cryptomonads to the lower Chesapeake Bay and its tributaries (Marshall, 1967a, 1967b, 1967c; Filardo and Dunstan, 1985; Marshall and Lacouture, 1986; Birdsong *et al.*, 1988).



The Nansemond River phytoplankton populations are similar to those reported in the James and Elizabeth Rivers (Marshall, 1967a, 1967b, 1968; Birdsong *et al.*, 1988). In contrast to the Nansemond River, the Elizabeth River has greater representation of oceanic species (e.g. *Coscinodiscus asteromphalus*, *C. perforatus*, *Rhizosolenia alata* and *Thalassiosira subtilis*), with freshwater flora more common in the James River (e.g. *Skeletonema potamos*, *Cyclotella striata*, *Microcystis* spp. and *Nostoc* spp.). Both the Elizabeth and Nansemond Rivers have little freshwater input and there is a low representation of freshwater species. The most abundant phytoplankters in the lower James, Nansemond and Elizabeth Rivers were *Skeletonema costatum* and several cryptomonads. Also, the dinoflagellates *Heterocapsa triquetra*, and *Katodinium rotundata* are abundant in the James and Nansemond Rivers, with *K. rotundata* also common in the Elizabeth River (O'Reilly, 1987). But most phytoplankton studies in the Elizabeth River have been short term and did not record high concentrations of dinoflagellates. However, even with these similarities of phytoplankton composition there is a marked environmental contrast between the Nansemond, the lower James and Elizabeth Rivers. The lower James and Elizabeth Rivers have extensive industrial and shoreline development, including port and harbor facilities and heavy boat traffic. The Elizabeth has been recognized as a highly polluted river and classified as an area of high toxic contamination by synthetic organics, heavy metals and numerous point sources of pollution (Virginia Water Control Board, 1986). Likewise, the James River has been described as experiencing water quality problems, especially in areas associated with high residential and industrial development such as Richmond and Hopewell. In contrast, the Nansemond has little growth or development along its shorelines, and may be one of the least polluted river in eastern Virginia.

Yet all three rivers have similar neritic and estuarine species that are apparently tolerant to the existing levels of environmental stress found in these river systems and are successful opportunists at these sites. They form an abundant and rich flora dominated by common species not suppressed by existing environmental conditions.

### SUMMARY

The phytoplankton of the Nansemond River contained two major size categories. The most numerous was a ubiquitous pico-nanoplankton component consisting mainly of cyanobacteria, microflagellates and chlorophyceans that were  $< 10 \mu\text{m}$  in size, with major growth periods in spring and fall. The second group was microplankton that contained cells generally  $> 10 \mu\text{m}$  and were composed primarily of species from the Bacillariophyceae, Dinophyceae, Cryptophyceae, Chlorophyceae, and Euglenophyceae. This group also had a bimodal abundance pattern occurring in spring and fall. The major phytoplankters in the Nansemond River were primarily estuarine species similar to populations previously reported in the lower James River, its tributaries and the lower Chesapeake Bay. The diatoms had seasonal means of 64.8% and 52.5% of the total biovolume for winter and spring respectively. The Dinophyceae were the most important contributor to biovolume in summer and the fall of 1985. The characteristic phytoplankton in the



Nansemond River were not unique, but have a wide distribution within the region and in the lower Chesapeake Bay.

#### LITERATURE CITED

- Brehmer, M.L., S.O. Hatiwanger and W.I. Simmonds. 1967. A Biological and Chemical Study of the Nansemond River, Virginia. Va. Inst. Mar. Sci. Spec. Rep. 9:66 pp.
- Birdsong, R.S., H.G. Marshall, R.W. Alden III and R.M. Ewing. 1988. Chesapeake Bay Plankton Monitoring Program. SP. Rep. Old Dominion University Research Foundation, Norfolk, VA. 136 pp.
- Cassie, R.M. 1963. Microdistribution of Plankton. Oceanogr. Mar. Biol. Ann. Rev. 1:223-252.
- Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes. EPS-600/4-79-020 United States Environmental Protection Agency, Cincinnati OH:365.3-1 to 365.3-4.
- Filardo, M.J. and W.M. Dunstan. 1985. Hydrodynamic Control of Phytoplankton in Low Salinity Waters of the James River Estuary, Virginia. Estuarine Coastal Shelf Sci. 21:653-667.
- Kovala, P.E. and J.D. Larrance. 1966. Computation of Cell Numbers, Cell Volume, Cell Surface and Plasma Volume per Liter, from Microscopical Counts. Dept. Oceanogr., Univ. Washington, Seattle. Sp. Rep. No. 38, 91 pp.
- Marshall, H.G. 1967a. Phytoplankton in the James River Estuary, Virginia I. Phytoplankton in Willoughby Bay and Hampton Roads. Ches. Sci. 8:90-101.
- Marshall, H.G. 1967b. Phytoplankton in the James River Estuary, Virginia II. Phytoplankton in the Elizabeth River. VA. J. Sci. 18:105-109.
- Marshall, H.G. 1967c. Observations on the Distribution of Phytoplankton in the Elizabeth River, Virginia. VA. J. Sci. 20:37-39.
- Marshall, H.G. 1968. Phytoplankton in the James River Estuary III. Phytoplankton in the Lafayette and Elizabeth Rivers (Western and Eastern branches). Castanea 33:255-258.
- Marshall, H.G. and R. Lacouture. 1986. Seasonal Patterns of Growth and Composition of Phytoplankton in the Lower Chesapeake Bay and Vicinity Estuarine Coastal Shelf Sci. 23:115-130.
- Mulford, R.A. 1972. Phytoplankton of the Chesapeake Bay. Ches. Sci. 13:S74-S81.
- O'Reilly, R.L. 1987. Short Term Spatial Variability of Phytoplankton in the Elizabeth River. M.S. Thesis, Dept. of Biol. Sci. Old Dominion Univ., Norfolk, VA., 80 pp.
- Purcell, T.W. 1975. Phytoplankton Species Composition in the Lafayette River Estuary, Norfolk, Virginia, 1971-1972. VA. J. Sci. 26:147-152.
- SAS Institute, Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. Cary, NC:SAS Institute Inc., 956 pp.
- Shomers, C.E. 1988. Seasonal Phytoplankton Assemblages in the Nansemond River, Virginia. M.S. Thesis, Dept. of Biol. Sci. Old Dominion Univ., Norfolk, VA, 90 pp.
- Shomers, C.E. and H.G. Marshall. 1987. Seasonal Observations of Phytoplankton in the James River. VA. J. of Sci. 38(2):88.

- Venrick, E.L. 1978. How Many Cells to Court. In: Sournia, A. (ED), *Phytoplankton Manual*. UNESCO, pp. 167-180.
- Virginia Water Control Board. 1986. *Virginia Water Quality Assessment*. Vol. II. Report to the Environmental Protection Agency and Congress #305b, Richmond, VA, 314 pp.

## **Efficacy of Two Feedthrough Larvicides in Comparison with Two Insecticide Impregnated Ear Tags for Control of Two Common Fly Pests of Dairy Cattle**

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### **ABSTRACT**

Disflubenzuron and stirofos feedthrough larvicides were compared with two formulations of insecticide impregnated ear tags for control of horn fly, face fly and stable fly when applied to non-lactating dairy cattle in southwestern Virginia. Five herds each received one of the four treatments plus a control herd. The results indicate that both the feedthrough larvicides significantly reduced the number of horn flies, while neither were as effective at controlling the face fly or stable fly. Neither of the feedthrough treatments were as effective as the ear tags for control of the horn fly or face fly. Data from a bioassay of manure collected in the two herds on the feedthrough ration and the control herd showed a significant reduction in the number of house fly larvae emerging from the treated manure.

### **INTRODUCTION**

The horn fly, *Hematobia irritans* L., has recently developed resistance to synthetic pyrethroid impregnated ear tags (Sheppard 1984, Kunz and Schmidt 1985, Schmidt *et al.* 1985 and Meyer and Kopp 1987). Constant exposure of horn flies to the insecticides in the tags will probably result in resistance to other insecticides used in the tags as well. Therefore alternative control methods are needed. This need has resulted in a renewed interest in insect growth regulators (IGRs) which, when administered orally to cattle inhibit the development of the fly larvae in the manure (Miller *et al.* 1984, 1986 and Scott *et al.* 1986). IGRs have been formulated as feedthroughs or sustained release boluses for control of horn fly and other manure breeding fly pests, such as face fly, *Musca autumnalis*, De Geer, stable fly, *Stomoxys calcitrans* L. and house fly, *Musca domestica* L.

This report discusses the results of feedthrough formulations of disflubenzuron and stirofos when used on pastured non-lactating dairy cows for control of non-resistant horn flies and face flies in southwestern Virginia. Some data on stable fly and house fly are also presented. The efficacy of the feedthrough IGRs are compared to two formulations of insecticide impregnated ear tags against horn flies and face flies.

### **MATERIALS AND METHODS**

Ninety mature non-lactating dairy cows (Holsteins) were weighed and divided into three groups of thirty animals each on the 22nd of June. Groups A, B, and C were fed a basic ration of corn, barley, and soybean meal with the appropriate



amount of larvicide. Group A received 0.0285 grams ai of diflubenzuron (American Cyanamid Co. Princeton, NJ) per kilogram of feed, Group B received 0.349 grams ai of stirofos (Fermenta Animal Health Co. Painesville, OH) per kilogram of feed, and Group C was used as a check. Two other groups of non-lactating heifers were used to evaluate two insecticide impregnated ear tags. Group D was treated with one tag per ear containing 10% Permethrin (Y-Tex Corp. Cody, WY) and group E with one tag per ear containing a combination of 7% Cypermethrin, 5% Chlorpyrifos, and 3.5% Piperonyl butoxide, technical ether and related compounds (Y-Tex Corp. Cody, WY). Groups A, B and C were monitored for horn fly, face fly, stable fly and house fly control. Groups D and E were monitored for horn fly and face fly control only. The animals were maintained in separate pastures but within one mile of each other. The cows in groups A, B and C were fed a concentrate ration of 2.27 kilograms per head per day and hay (*ad lib*). On 11 August it was determined that the cows were gaining too much weight so the amount of feed was reduced to 1.14 kilograms per head per day, the amount of diflubenzuron and stirofos were doubled to .057 grams and .698 grams per kilogram of feed to maintain the concentration of the larvicides the same.

The efficacy of the larvicides were evaluated by making weekly fly counts on 10 animals in each group for 12 weeks. The number of horn flies were recorded for one side of the body. For face flies, only those flies on the front of the face were recorded. For stable flies, only those flies seen on the legs when viewed from one side of the animal were recorded.

A bioassay was conducted by collecting five fresh manure samples (less than 24 hrs. old) from groups A, B and C every week. The manure samples were frozen and stored until the end of the test. After all manure samples had been collected they were thawed and 300 gm of manure from each sample was placed into a (0.95 liter) plastic container. House fly larvae were chosen to place in the manure because they were readily available. Twenty-five first instar house fly larvae were placed on the manure in the container. The containers were covered with screen and placed in a room at 25°C. One week after the larvae were placed into the containers, vermiculite was spread over the top of the manure *ca.* 1 cm deep to provide a favorable pupation site. After the adult flies emerged, they were allowed to die and then they were removed from the containers and counted.

The data from the fly counts and the bioassay were subjected to analysis of variance (Proc ANOVA, SAS 1985) and to the Least Significant Difference (LSD) means separation test ( $P=0.05$ ) (SAS 1985).

The effect on nontarget organisms was evaluated by collecting five manure samples at monthly intervals from groups A, B and C. The samples were placed in rearing containers at 25°C. When the adult insects emerged they were placed in 80% EOH and specimens were identified to family and tabulated.

## RESULTS AND DISCUSSION

The results indicate that both feedthrough larvicides significantly reduced the number of horn flies, while neither were as effective at controlling the face fly or stable fly (Table 1-2). This is not surprising since face flies are known to migrate long distances from untreated areas into pastures in which the animals were treated with feed-through larvicides (Wallace and Turner 1964). Stable flies do not

TABLE 1. Mean weekly horn fly counts on dairy cattle when comparing stirofos and diflubenzuron feedthrough larvicides to two ear tag formulations and a control. (June 14-Sept. 3, 1986)

Week	Group				
	D	E	B	A	C
	Tag A <sup>1</sup>	Tag B <sup>2</sup>	Stirofos	Diflubenzuron	control
0	16.9b <sup>3</sup>	17.6b	12.4ab	8.7a	11.8ab
1	0.6a	0.1a	19.8b	20.0b	20.1b
2	1.2ab	0.5a	5.9b	6.4b	19.9c
3	0.5a	0.0a	7.6b	8.3b	21.2c
4	0.1a	0.9a	0.8a	5.5b	0.0c
5	0.2a	0.2a	0.4a	3.1b	41.1c
6	0.2ab	0.0a	4.8c	2.2bc	21.0d
7	0.4a	0.6a	9.7b	19.2c	5.2c
8	0.3a	0.9ab	5.0b	14.0c	32.9d
9	0.0a	0.1a	16.9b	11.3b	35.9c
10	0.1a	0.0a	10.0b	13.1b	54.5c
11	0.0a	0.0a	3.5c	10.4b	45.0c
12	0.0a	0.0a	12.4b	5.8b	45.0c

<sup>1</sup>Tag A 10% Permethrin<sup>2</sup>Tag B 7% Cypermethrin, 5% Chlorpyrifos, and 3.5% Piperonyl butoxide, technical ether and related compounds<sup>3</sup>Those numbers in the same row followed by the same letter are not significantly different ( $P=0.05$ ) LSD. Due to the high number of zeros the data was transformed by the formula  $\text{SQRT}(X + 0.05)$  for the ANOVA and LSD tests. The transformed data is not presented here.

normally breed in field manure and therefore could not be adversely affected by the oral larvicides.

Neither of the diflubenzuron and stirofos feedthrough treatments were as effective as the Permethrin and the combination (cypermethrin and chlorpyrifos) eartags for control of the horn fly or the face fly (Table 1-2). Scott *et al.* (1986) previously reported that Flucythrinate ear tags were more effective than the stirofos oral larvicide or the diflubenzuron bolus.

The results of the bioassay showed statistical difference in house fly emergence between the treatment groups A and B and the control group C (Table 4). The mean emergence of 45% for diflubenzuron and 35% for stirofos were too high to be considered adequate control. Feeding the larvicides *ad lib.* would lead to dosage variation and hence varying results in the bioassay. The house fly may be less sensitive than horn fly and undiluted manure is not its natural breeding habitat. These factors and others may have led to the unsatisfactory control.

The results of the tests on nontarget organisms indicate little effect on them (Table 5). The data was not subjected to statistical analysis. During the month of August the totals of the mean emergence of nontarget organism for the diflubenzuron, stirofos and control groups were 138, 117 and 127 respectively. The highest emergence of nontarget insects was seen in the diflubenzuron group indicating little effect particularly for the Scarabaeidae and Staphylinidae (Order Coleoptera). These two families are important nontarget organisms.

TABLE 2. Mean weekly face fly counts on dairy cattle when comparing stirofos and diflubenzuron feedthrough larvicides to two ear tag formulations and a control. (June 14-Sept.3, 1986)

Week	Group				
	D	E	B	A	C
	Tag A <sup>1</sup>	Tag B <sup>2</sup>	Stirofos	Diflubenzuron	control
0	2.0a <sup>3</sup>	2.3a	3.6ab	6.5c	6.6bc
1	1.3ab	0.2a	3.0bc	5.1c	9.4d
2	1.3ab	0.9a	2.9ab	3.4bc	6.4c
3	0.5a	0.2a	3.7c	1.5b	1.5b
4	0.6a	3.5b	3.0ab	1.1a	2.9b
5	1.7a	1.1a	5.5b	2.6ab	2.7ab
6	1.6ab	0.3a	4.2c	4.3c	2.9bc
7	1.6a	1.2a	5.2b	6.6b	4.8b
8	0.2a	0.8a	4.7bc	2.6b	4.7c
9	1.4b	0.0a	0.7ab	0.6ab	1.1b
10	1.1ab	0.2a	1.2b	1.7b	1.3b
11	0.0a	0.0a	0.1a	0.3ab	0.5b
12	0.0a	0.0a	0.3b	0.0a	0.0a

<sup>1</sup>Tag A 10% Permethrin<sup>2</sup>Tag B 7% Cypermethrin, 5% Chlorpyrifos, and 3.5% Piperonyl butoxide, technical ether and related compounds<sup>3</sup>Those numbers in the same row followed by the same letter are not significantly different ( $P = 0.05$ ) LSD. Due to the high number of zeros the data was transformed by the formula  $\text{SQRT}(X + 0.05)$  for the ANOVA and LSD tests. The transformed data is not presented here.

TABLE 3. Mean weekly stable fly counts on dairy cattle when comparing stirofos and diflubenzuron feedthrough larvicides to a control. (June 14-Sept.3, 1986)

Week	Group		
	B	A	C
	Stirofos	Dflubenzuron	control
0	4.7a <sup>1</sup>	4.3a	--
1	0.6ab	1.7b	0.0a
2	1.0a	0.6a	0.9a
3	1.0a	0.7a	0.8a
4	0.2a	0.6a	2.8b
5	0.6a	0.6a	1.5a
6	0.6a	1.1a	5.8b
7	0.9a	2.9a	1.5a
8	1.2a	1.3a	1.2a
9	0.8a	0.3a	16.1b
10	0.2a	1.1a	3.6b
11	0.0a	0.4a	1.4b
12	0.6a	0.4a	1.0a

<sup>1</sup>Those numbers in the same row followed by the same letter are not significantly different ( $P = 0.05$ ) LSD. Due to the high number of zeros the data was transformed by the formula  $\text{SQRT}(X + 0.05)$  for the ANOVA and LSD tests. The transformed data is not presented here.



TABLE 4. Bioassay results: Number of house flies emerged (out of 25) from manure collected less than 24 hr of excretion from dairy cattle fed stirofos and diflubenzuron and compared to a control group. (June 14-Sept.3, 1986)

Week	Number of flies		
	Group		
	B	A	C
	Stirofos	Diflubenzuron	Check
0	12.2a <sup>1</sup>	13.4a	21.8a
2	10.4a	13.2a	20.8b
4	6.2a	11.2a	19.0b
6	8.4a	8.0a	18.2b
8	10.0a	11.8a	20.2b
10	7.8a	11.0ab	17.8b
12	6.2a	10.2ab	18.2b
Mean	8.74	11.25	18.

<sup>1</sup>Those numbers in the same row followed by the same letter are not significantly different ( $P = 0.05$ ) LSD (SAS 1985).

TABLE 5. Monthly totals for nontarget insects that emerged from manure collected from dairy cattle fed stirofos and diflubenzuron.

Month	Treat	Family <sup>1</sup>					
		Scarab	Staph	Sarcoph	Calliph	Musc	UnDipt
July	Stirof	0	0	0	0	0	0
July	Diflu	0	0	0	0	0	0
July	Check	1	0	7	7	23	0
August	Stirof	31	34	24	0	0	28
August	Diflu	59	78	0	0	0	1
August	Check	65	16	2	0	5	44
Sept	Stirof	1	1	0	0	0	81
Sept	Diflu	3	0	0	1	2	0
Sept	Check	8	1	6	0	1	25

<sup>1</sup>Scarab - Scarabaeidae (Coleoptera)

Staph - Staphylinidae (Coleoptera)

Sarcoph - Sarcophagidae (Diptera)

Calliph - Calliphoridae (Diptera)

Musc - Muscidae (Diptera)

UnDipt - Unknown (Diptera)

## LITERATURE CITED

- Kunz, S.E., and Schmidt. 1985. The pyrethroid resistance problem in the horn fly. *J. Agric. Entomol.* 2:358-363.
- Meyer, H.J., and D.D. Kopp. 1987. Pyrethroid resistance in North Dakota horn flies. *J. Agric. Entomol.* 4:132-135.
- Miller, R.W., L.G. Pickens, and D.M. Nafus. 1984. Use of white tetrahedral traps and stirofos oral larvicide for area-wide control of the face fly. *J. Agric. Entomol.* 1:126-136.
- Miller, J.A., F.W. Knapp, R.W. Miller, C.W. Pitts, and J. Weintraub. 1986. Diflubenzuron bolus for control of fly larvae. *J. Agric. Entomol.* 3:48-55.
- Schmidt, C.K., S.E. Kunz, H.D. Peterson, and J.L. Robertson. 1985. Resistance of horn flies (Diptera: Muscidae) to permethrin and fenvalerate. *J. Econ. Entomol.* 78: 402-406.
- Scott, Thomas W., Richard W. Miller, and Fred W. Knapp. 1986. Field evaluation of diflubenzuron bolus with and without flucythrinate ear tags for control of horn flies, *Haematobia irritans*, and face flies, *Musca autumnalis*, on pastured cattle. *J. Agric. Entomol.* 3:105-113.
- Sheppard, D.C. 1984. Fenvalerate and flucythrinate resistance in a horn fly population. *J. Agric. Entomol.* 1:305-310.
- Wallace, J.B. and E.C. Turner Jr. 1964. Low-level feeding of ronnel in a mineral salt mixture for area control of the face fly, *Musca autumnalis*. *J. Econ. Entomol.* 57:264-267.

## A Comparison of Photosynthetic Enzyme Activities and Leaf Anatomies between *Zea diploperennis* and *Zea mays*

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### ABSTRACT

Photosynthetic enzyme activities and leaf anatomies of *Zea diploperennis*, a diploid perennial maize ally, were compared to those of *Zea mays* (var. Early Sunglow), a common sweet corn. The leaf anatomy of *Z. diploperennis* exhibited typical C<sub>4</sub> features and was similar to that of *Z. mays*. No observable differences for rates of NADP-Malate Dehydrogenase, Pyruvate Orthophosphate Dikinase, or RuBP Carboxylase activities existed between species. Levels of PEP Carboxylase and NADP-Malic Enzyme activities from *Z. diploperennis* samples were lower than those from *Z. mays*. Preliminary observations of similarities between leaf anatomies and photosynthetic enzymology of the two species, combined with their similar genomes, provide a basis for future comparative investigation and suggest the importance of further consideration of *Z. diploperennis* as a potential agricultural species.

### INTRODUCTION

The annual C<sub>4</sub> species *Zea mays* L. (maize) is among the world's most economically important crop species. Interest in improving existing varieties of maize has long been expressed by plant breeders who have sought related species having similar genomes to that of maize and having desirable characteristics for use in hybridization studies. Such characteristics include higher productivity, pathogen resistance, and perenniality. One species which exhibits such characteristics and has been the subject of successful genetic compatibility studies is the perennial species *Zea diploperennis* Iltis, Doebley, Guzman (Pasupuleti and Galinat, 1982).

*Zea diploperennis* was believed to be extinct until its rediscovery in 1978 in southern Jalisco, Mexico, where it occurs naturally along small streams and tributaries (Doebley and Iltis, 1980). The importance of this rediscovery is seen in the direct potential of *Z. diploperennis* as a crop species. It exhibits superior resistance to certain maize pathogens (Nault, 1980, 1985) and has strong potential for use as silage because of the high level of biomass it produces.

In addition to its direct crop potential, *Z. diploperennis* is important because of its potential for hybridization with maize. *Zea diploperennis* exhibits regular meiosis and normal fertility (Pasupuleti and Galinat, 1982). It contains no observable chromosomal irregularities, and its chromosomal lengths and arm ratios

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correspond closely to that of maize (Pasupuleti and Galinat, 1982). Since the base chromosome number of both species is ten (Doebley, 1983) and meiosis is usually regular in hybrids produced from parents of the genus *Zea* (Pasupuleti and Galinat, 1982), it is plausible that perennial hybrids exhibiting higher pathogen resistance and/or higher biomass production than *Z. mays* could result. This suggestion is strengthened by the fact that viable hybrids of *Z. diploperennis* and *Z. mays* having 95% fertile pollen have already been produced (Nault, 1985; Pasupuleti and Galinat, 1982).

Despite great interest in the hybridization potential of *Z. diploperennis*, little has been done to characterize photosynthetic properties for this perennial corn ally. Such characterization is essential as a basis for quantitative comparisons of specific *Z. diploperennis*/*Z. mays* hybrids with respect to levels of inheritance of productivity-related traits. Our purpose, therefore, has been to undertake investigations relating carbon fixation rates, photosynthetic enzymology, photosynthate partitioning, and leaf anatomies of *Z. diploperennis* to those of common varieties of maize. We consider these several interrelated parameters to be among the most characteristic indicators of photosynthetic productivity. This initial study specifically compares leaf anatomies and key photosynthetic enzyme activities from *Zea diploperennis* to those from *Zea mays* (var. Early Sunglow). The interrelation of leaf anatomy and photosynthetic enzymology in C<sub>4</sub> plant species is critical to photosynthetic characterization since the enzyme-mediated fixation of atmospheric CO<sub>2</sub> and subsequent assimilation of carbon into glucose occur in different cell types within the characteristic C<sub>4</sub> Kranz leaf anatomy. A well developed Kranz anatomy is therefore essential for expression of efficient C<sub>4</sub> photosynthetic metabolism. The most critical enzymes in the process are those considered in this study, namely phosphoenolpyruvate carboxylase (PEPcase), NADP-malate dehydrogenase (NADP-MDH), NADP-malic enzyme (NADP-ME), pyruvate orthophosphate dikinase (PPiDK) and ribulose-1,5-bisphosphate carboxylase (RuBPCase). These enzymes function to combine atmospheric CO<sub>2</sub> with phosphoenolpyruvate, to reduce the resulting oxaloacetic acid to malate, to decarboxylate malate yielding CO<sub>2</sub> and pyruvate, to regenerate phosphoenolpyruvate from the pyruvate, and to assimilate the CO<sub>2</sub> into Calvin cycle intermediates, respectively.

## MATERIALS AND METHODS

### Plant Material:

Specimens of *Zea diploperennis* and *Zea mays* (var. Early Sunglow) were grown from seeds in vermiculite. Seeds were initially treated with fungicide, watered daily, and given Peter's nutrient solution weekly. Plants were grown under natural illumination in a greenhouse at Liberty University from September through December, 1988.

### Enzyme Assays and Chlorophyll Determination:

Tissue samples from the second fully expanded leaf pair of eight-to nine-week old plants of each species were used to extract enzymes as previously described (Littlejohn and Ku, 1984). PEPcase, NADP-MDH and NADP-ME, PPiDK, and RuBPCase were assayed spectrophotometrically according to methods described by Uedan and Sugiyama (1976), Kanai and Edwards (1973), Sugiyama (1973), and

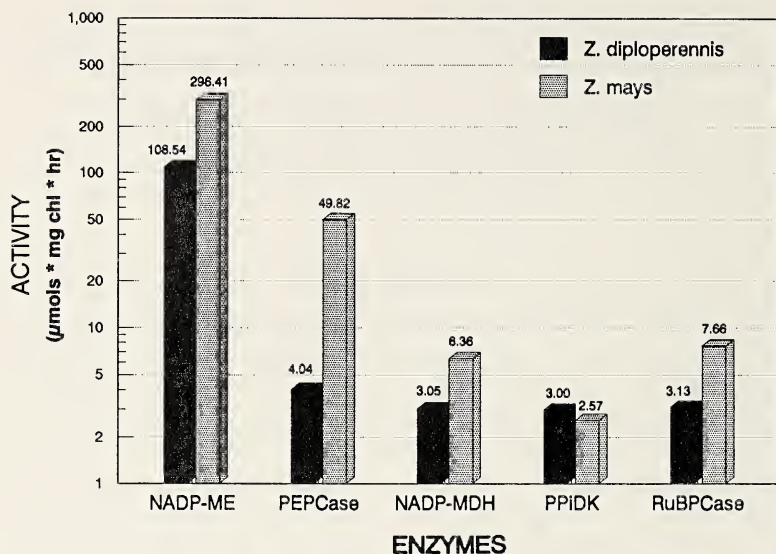


FIGURE 1. Activities of NADP-malic enzyme, pyruvate orthophosphate dikinase, NADP-malate dehydrogenase, phosphoenolpyruvate carboxylase, and ribulose-1,5-bisphosphate carboxylase from specimens of *Zea diploperennis* and *Zea mays*.

Usuda (1985, modified), respectively. Three to five replicates of each assay were performed for both species. Chlorophyll concentrations were determined according to Arnon (1949).

#### Anatomical Studies:

Tissue samples were excised from the second leaf pair of eight- to nine-week old plants, fixed in CRAF III (Berlyn and Miksch, 1976), and embedded in Paraplast. Tissues were cross sectioned at twelve  $\mu\text{m}$  and stained with 0.5% saffranin and 0.1% fast green counterstain. Tissues were examined and photographed using light microscopy.

## RESULTS

#### Enzymology:

The rate of PEPcase activity for *Z. diploperennis* was  $4.04 \pm 0.79$  mol. mg chl-1 . hr-1 (mean  $\pm$  standard error) while that for *Z. mays* was 49.82 (mean of fewer than three replicates, Figure 1). NADP-ME activities for both species were much higher, with *Z. diploperennis* having a rate of 108.54 and *Z. mays* having a rate of  $296.41 \pm 11.15$ . *Zea diploperennis* exhibited an NADP-MDH rate of  $3.05 \pm 0.48$ , while that of *Z. mays* was 6.36. RuBPCase activities for both species were similar in range to those for NADP-MDH, with *Z. diploperennis* exhibiting a rate of  $3.13 \pm 0.81$ , and maize exhibiting a rate of 7.66. PPiDK rates for the two species were similar, with *Z. mays* having a rate of 2.57 and *Z. diploperennis* having a rate of  $3.00 \pm 0.38$  (Figure 1).

#### Anatomy:

Despite the fragile nature of *Zea diploperennis* tissue, as evidenced by loss of the epidermis during sectioning, leaf anatomies of the two species were very similar



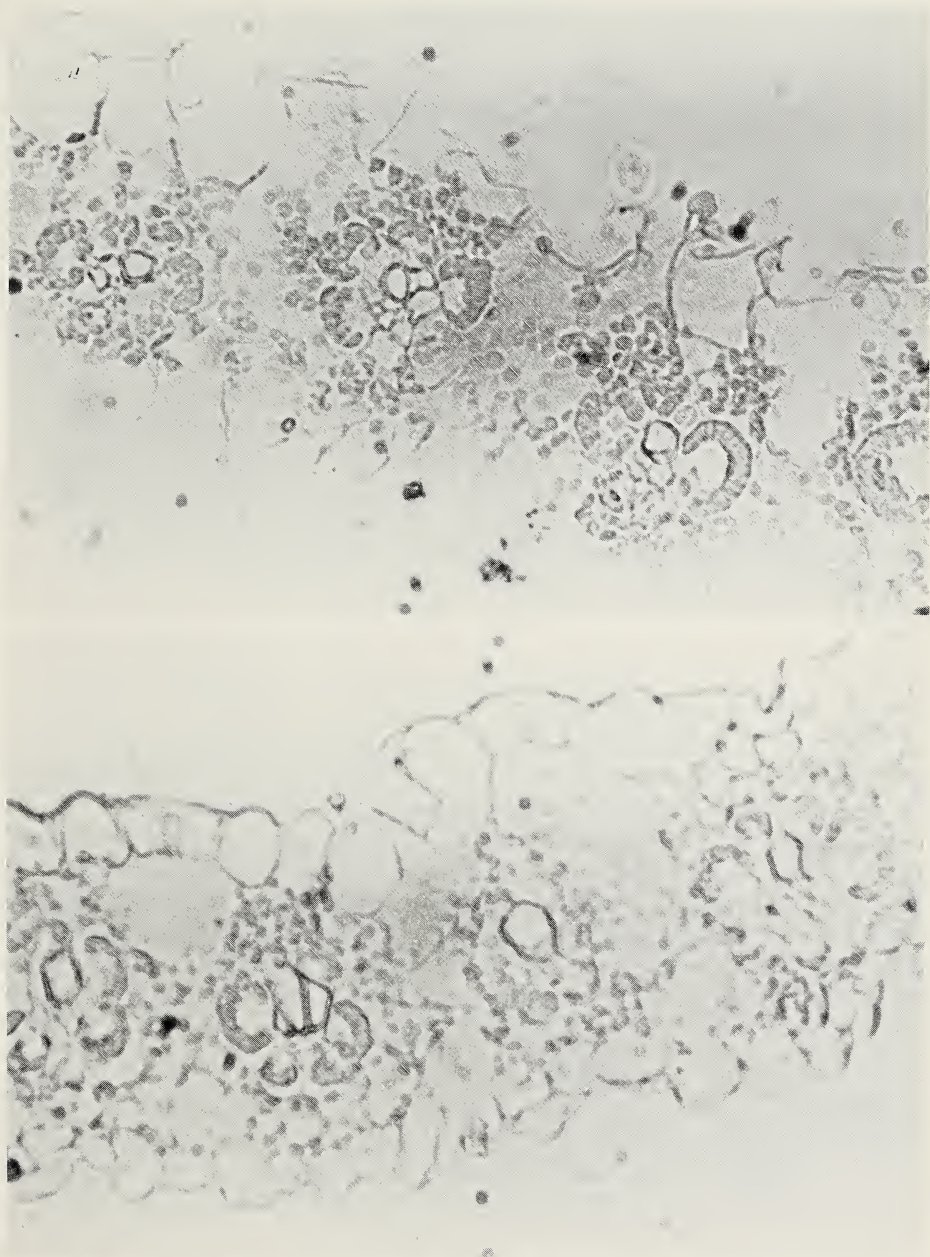


FIGURE 2. Twelve- $\mu$  m Cross sections of *Zea diploperennis* (upper photo) and *Zea mays* (lower photo) leaves. Magnification = 400x.

(Figure 2) and exhibited typical Kranz cellular arrangement, with the bundle sheath cells arranged concentrically around the vascular bundles, separating them from the mesophyll (Laetsch, 1974). The centrifugal arrangement of the chloroplasts in the bundle sheath cells was particularly apparent (Figure 2), and is typical of NADP-malic enzyme type C<sub>4</sub> species (Hatch *et al.*, 1975).



## DISCUSSION

Enzyme activity levels observed for autumn-grown specimens of both *Zea diploperennis* and *Zea mays* were considerably lower than those commonly reported for spring- or summer-grown C<sub>4</sub> plants or for those grown in controlled environments (Edwards and Walker, 1983). These observations may be largely due to cooler temperatures, shortening day length, and/or frequent overcast conditions typical of autumn in Central Virginia. Despite minimal apparent photosynthetic activity in *Z. diploperennis* (photosynthetic rates presumably would be biochemically limited by low activities of the photosynthetic enzymes), values for NADP-MDH, PPiDK, and RuBPCase were not observed to be substantially different from those for *Z. mays* plants grown under identical conditions. These enzymatic similarities are consistent with the distinctive C<sub>4</sub> (maize-like) leaf anatomy observed for the specimens of *Z. diploperennis*. In contrast, the striking differences between levels of PEPCase and NADP-ME activities for the two species are somewhat puzzling. The lower activities of these enzymes in *Z. diploperennis* may have been due in part to the greater divergence from native day length conditions experienced by these plants than by *Z. mays* plants which are the result of selective breeding for cultivation at more northern latitudes. Whatever the reason, the lower enzyme rates observed for *Z. diploperennis* are consistent with its slower rate of growth. Continued observations of growth patterns after conclusion of experimentation revealed that year-old *Z. diploperennis* plants, though high in biomass production, exhibited far slower rates of growth than did newly planted maize varieties and F1 hybrid specimens.

These preliminary observations of *Zea diploperennis* leaf anatomy and photosynthetic enzymology begin to establish the needed basis for future comparative studies of *Z. diploperennis*, *Z. mays* and their hybrids. The observed similarities between the *Zea* species, combined with their similar genomes (Pasupuleti and Galinat, 1982; Doebley, 1983), suggest the importance of further consideration of *Z. diploperennis* and its hybrids with maize for potential agricultural use. Justification is also evident from this study of "off-season" specimens for investigation of photosynthetic enzymology and other photosynthetic characteristics for spring- and summer-grown garden specimens and for controlled environment studies of *Zea diploperennis*.

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## LITERATURE CITED

- Arnon, D. 1949. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in *Beta vulgaris*. *Plant Physiol.* 24:1-15.
- Berlyn, G.P. and J.P. Miksch. 1976. *Botanical microtechnique and cytochemistry*. Iowa State University Press, Ames, Iowa. 326pp.
- Doebley, J.F. 1983. The maize and teosinte male inflorescence: a numerical taxonomic study. *Ann. Missouri Bot. Gard.* 70:32-70.

- Doebley, J.F. and H.H. Iltis. 1980. Taxonomy of *Zea* (Gramineae). I. A subgeneric classification with key to taxa. Amer.J.Bot. 67(6):982-993.
- Edwards, G. and D.A. Walker. 1983. C<sub>3</sub>, C<sub>4</sub>: Mechanisms, and cellular and environmental regulation, of photosynthesis. University of California Press, Los Angeles. 542pp.
- Hatch, M.D., T. Kagawa and S. Craig. 1975. Subdivision of C<sub>4</sub>-pathway species based on differing C<sub>4</sub> acid decarboxylating systems and ultrastructural features. Aust.J.Plant Physiol. 2:111-128.
- Kanai, R. and G.E. Edwards. 1973. Separation of mesophyll protoplasts and bundle sheath cells from maize leaves for photosynthetic studies. Plant Physiol. 51:1133-1137.
- Laetsch, W.M. 1974. The C-4 syndrome: A structural analysis. Ann.Rev.Plant Physiol. 25:27-52.
- Littlejohn, R.O. and M.S.B. Ku. 1984. Characterization of early morning Crassulacean acid metabolism in *Opuntia erinacea* var *Columbiana* (Griffiths) L. Benson. Plant Physiol. 74:1050-1054.
- Nault, L.R. 1980. Maize bushy stunt and corn stunt: A comparison of disease symptoms, pathogen host ranges, and vectors. Am.Phytopathol Soc. 70:659-662.
- Nault, L.R. 1985. Evolutionary relationships between maize leafhoppers and their host plants. In LR Nault, JG Rodriguez, eds. The Leafhoppers and Planthoppers. John Wiley and Sons, New York. pp 309-330.
- Pasupuleti, C.V. and W.C. Galinat. 1982. *Zea diploperennis*. I. Its chromosomes and comparative cytology. J.Hered. 73:168- 170.
- Sugiyama, T. 1973. Purification, molecular, and catalytic properties of pyruvate phosphate dikinase from the maize leaf. Biochemistry. 12:2862-2868.
- Uedan, K. and T. Sugiyama. 1976. Purification and characterization of phosphoenolpyruvate carboxylase from maize leaves. Plant Physiol. 57:906-910.
- Usuda, H. 1985. The activation state of ribulose 1,5- bisphosphate carboxylase in maize leaves in dark and light. Plant Cell Physiol. 26(8):1455-1463.



## **Additions to the Diatoms of Virginia's Inland Fresh Waters: Lake Barcroft, Fairfax County, VA**

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### **ABSTRACT**

From 5 May 1979 through 24 October 1979, benthic, epiphytic, and planktonic diatom samples were collected from Lake Barcroft, Fairfax County, Virginia. A total of 177 samples were collected, with several hundred diatom valves identified from each sample. From these observations, 179 diatom taxa representing 29 genera were identified. Hufford (1987) recognized 367 validly published diatoms from Virginia inland waters. The present study reports on 74 diatom taxa from Lake Barcroft not previously published for Virginia inland waters, thus raising the total taxa reported for Virginia to 441 for the Commonwealth.

### **INTRODUCTION**

Addenda or additions to a State's list of species for a particular group will sometimes include rare or little known taxa, or more often will list subspecies, varieties, or forms. The present addition to the diatoms of Virginia is no exception, at least in regard to the latter instance. One must therefore be mindful of the criteria by which these taxa are to be judged.

Hustedt (1930,1959), was perhaps the best known of a number of diatomists who have pointed out the tendency of many diatom species toward considerable morphological variability. He states, "I have repeatedly pointed out that certain variations appear regularly in the course of development of many species, thus producing small odd varieties with taxonomic independence." He continues by referring to the influence of ecological or mechanical influence on the unsilicified reproductive stage and the consequence of fluctuating nongenetic variabilities which produce, in his words, "ridiculously unimportant differences." True varieties are genetically distinct from the species and therefore should not integrate with it.

Within the diatoms, each species has a certain amplitude of variation within which deviations occur. This amplitude of variation may result in close resemblance of forms. These forms simply represent convergence phenomena found in the natural range of each species. These cannot be perceived as transition forms even though they are separated ecologically and, to a degree, morphologically. In accordance with Hustedt's (1930) interpretation of species limits, decisions about certain taxa in this research leading to separation are based on morphological criteria alone. Even though certain ecological conditions were



evaluated for Lake Barcroft, it was felt that members of the same species, when separated ecologically, do not necessarily build transition forms.

While the present work does list a number of varieties or forms, we have attempted to be as conservative as possible in our taxonomy. We are of the same mind as Hustedt (1959) that to combine forms that should not be combined is as great an error as to separate those which should not be separated. Thus, we have chosen not to consider such recent works as Lange-Bertalot (1977, 1980a, 1980b, 1980c, 1980d), Lange-Bertalot & Simonsen (1978), Lange-Bertalot & Ruppel (1980), Krammer (1980), Moss & Carter (1982), Archibald & Schoeman (1984), Krammer & Lange-Bertalot (1985), Williams (1985) and Lange-Bertalot & Krammer (1987), in this compilation.

### STUDY AREA

Lake Barcroft and its tributaries (figure 1) are located in Fairfax County, Virginia, east of the City of Fairfax. The two major tributaries are Holmes Run which drain an area of about 7.2 square miles (1860 hectares) and Tripps Run that has a watershed of approximately 5.0 square miles (1297 hectares). An additional 547 hectares drain directly into Lake Barcroft. The Lake drains, via Holmes Run, into the Potomac River. The majority of both sub-basins is classified as medium density residential area. The lake was originally developed as a water supply reservoir owned by the Alexandria Water Company, and was impounded in 1915. Its surface area is approximately 53 hectares at full pool.

In 1950 Lake Barcroft was sold to developers and became a private lake for recreational use. The Lake Barcroft Watershed Improvement District, which is incorporated under the Northern Virginia Soil and Water Conservation District, presently maintains and operates the dam located at the east end of the lake. There is also an on-going program of water quality maintenance and surveillance to ensure the continued suitability of the lake as a recreational resource. The Lake Barcroft Community Association was formed in the early 1950's to provide local support in maintaining and monitoring lake quality.

In 1960, a dredging program began in an effort to forestall increasing eutrophication that was occurring because of inputs of fertilizer nutrients and other pollutants from the watershed. In 1972, an earthen plug of the dam was eroded by flood waters from Hurricane Agnes and the dam was reconstructed dry season which followed. During that dry period, the lake bottom underwent extensive silt removal. Since that time, repeated silt removal has continued to keep the water at least 1.5 meters deep everywhere in the lake, and the depth at the dam is 14.6 meters.

### MATERIALS AND METHODS

Sampling of Lake Barcroft began 5 May 1979 and continued until 24 October 1979. Sixteen sampling stations were visited every two-to-three weeks during the survey period. The number and type of samples collected at each station varied, with a total of 24 different samples being taken regularly (see Figure 1, of Sample Stations). The samples were taken from both artificial and natural substrates, and water samples of natural substrates were obtained from squeezings, scrapings of living and decomposing vegetable material and rock surfaces.

The artificial substrates were exposed for a two or three-week period. The duration of this period was based upon the season and the amount of colonization

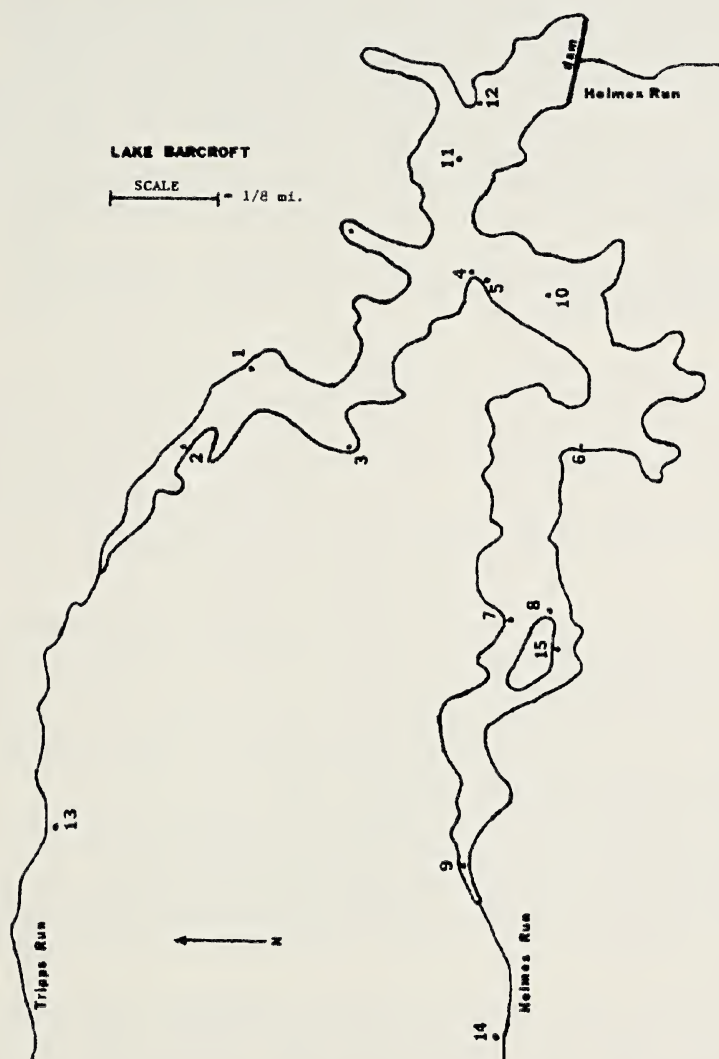
Key to FIGURE 1: Sampling Overview-Station Number and Sample Types

STATION NUMBER	SAMPLE TYPE	ABBREVIATIONS FOR SAMPLE TYPES	
1	D	D	Diatometer
2	RS, SS, BS, S	RS	Rock Scraping
3	D	SS	Surface Sediment
4	RS	BS	Tree Branch Scrapings
5	D	S	Squeezings
6	D	P	Planktonic
7	RS, SS, BS, S	PS	Aquatic Plant Scrapings
8	RS, S		
9	RS		
10	P		
11	P		
12	D		
13	D		
14	D		
15	PS		

present. During late winter/early spring and late summer/early fall, three-week periods of exposure provided adequate colonization of the slides. During late spring/summer, colonization was sufficient after two weeks of exposure.

Following exposure, the slides were removed, placed in a plastic slide box and returned to the laboratory. The diatoms were removed from the slides using a rubber policeman or a flat wooden toothpick. Following this treatment, the slides were scraped with a clean, single edge razor blade to remove tightly adhering forms. After 10 to 24 hours, a small aliquot of sample was removed and mounted on slides. This uncleaned material allowed for examination of weakly silicified forms. The remainder of the sample was cleaned by the hydrogen peroxide potassium dichromate method of Van der Werff (1953). Aliquots of uncleaned and cleaned diatoms were mounted on glass slides according to the method of Patrick and Reimer (1966).

FIGURE 1. Aerial View of Lake Barcroft



Collections were also made from various natural substrates which included submerged rocks, rotting branches, rooted aquatics, submerged algal mats floating algal mats, and surface layers of bottom sediments. Samples from rocks were removed via scraping (light abrasion with a rubber policeman) or by short exposure to ultrasonic sound using an ultrasonic probe (Labsonic Systems: Labline model Ultra Tip). Expendable samples were used to determine the optimum level for ultrasonic treatment to minimize breakage of the frustule while loosening diatoms that would otherwise remain tightly affixed to the rock surface. Other natural substrates were sampled on site by scraping with a pocket knife, and samples of rooted aquatics, submerged algal mats, or floating algal mats were taken either as



grab samples or squeezings. Samples from bottom sediments were taken only at shallow depths ( 1 m) using a four-foot length of glass tubing with a large capacity squeeze bulb to facilitate gentle siphoning of only the uppermost sediment layer. All samples were returned to the laboratory for cleaning and mounting.

Planktonic samples were obtained initially using a nanno-plankton net, but this method was unsatisfactory due to clogging by filamentous algae. As an alternative, five gallons of water were collected by submerging a five gallon carboy approximately 0.5 m below water surface. These samples were returned to the laboratory where 15 ml of Lugols solution (IKI) were added and mixed with the sample. After 24 hours, the water was decanted to a volume of 1000 ml. This mixture was allowed to settle for an additional 24 hours and then decanted to 50 ml. Planktonic samples were then processed into permanent slides using the methods described earlier.

### RESULTS

A total of 179 diatom taxa were identified from Lake Barcroft. Of these, 74 taxa have not previously been reported from Virginia inland waters and are reported here. These new taxa are illustrated in photographic plates 1-4. As in the Hufford (1987) paper, Patrick and Reimer (1966, 1975) was utilized as the authority for the nomenclature employed. In instances where the taxon was not reported by Patrick and Reimer, Van Landingham (1967-1969) served as authority.

### LITERATURE CITED

- Archibald, R.E.M. & F.R. Schoeman. 1984. "Amphora coffeaeformis" (Agardh) Kutzing: A revision of the species under light and electron microscopy. South African Journal of Botany 3(2):83- 102.
- Hufford, Terry L. 1987. A compilation of published reports of diatoms from Virginia fresh waters, exclusive of the Potomac River boundary waters. Virginia Journal of Science 38(3): 171- 193.
- Hustedt, Frederick. 1930. Bacillariophyta. In A. Pashers's Die Susswasser-Flora Mitteleuropas. Volume 10, pp. 1-446. Gustav Fischer, Jena.
- \_\_\_\_\_. 1959. *Die Kieselalgen Deutschlands, Osterreichs und der Schweiz unter Berucksichtigung der ubrigen Landen Europas sowie der angrenzenden Meeresgebiete*. Band 7, Teil 2, Lief. 6. 108pp., 73 figs. Akademische Verlagsgesellschaft leipzig.
- Kalinsky, Robert. 1969. The winter periphyton community of Big Walnut Creek, Franklin County, Ohio. Unpublished Thesis. The Ohio State University.
- Krammer, K. 1980. Morphologic and taxonomic investigations of some freshwater species of the diatom genus "Amphora" Ehr. "Bacillaria" 3: 197-225.
- \_\_\_\_\_. & H. Lange-Bertalot. 1985. Naviculaceae: Neue und wenig bekannte Taxa, neue Kombinationen und Synonyme sowie Bemerkungen zu einigen Gattungen. Bibliotheca Diatomologica 9:5-230.
- Lange-Bertalot, Horst. 1977. Eine Revision zur Taxonomie der Nitzschiae Lancelolatae Grunow. Nova Hedwigia 28:253-307.
- \_\_\_\_\_. 1980a. Zur systematischen Bewertung der bandformigen Kolonien bei "Navicula" und "Fragilaria": Kriterien fur die Vereinigung von "Synedra" (subgen. Synedra) Ehrenberg mit "Fragilaria" Lyngbye. Nova Hedwigia 33:723-787.

- \_\_\_\_\_ 1980b. New species, combinations and synonyms in the genus "Nitzschia", *Bacillaria* 3:41-77.
- \_\_\_\_\_ 1980c. Ein beitraq zur Revision der Gattungen "Rhoicosphenia" Grun., "Gomphonema" C.Ag., "Gomphoneis" Cl. Botanische Notiser 133:585-594.
- \_\_\_\_\_ 1980d. Zur taxonomischen Revision einiger okologisch wichtiger "Naviculae lineolata" Cleve: Die Formenkreise um "Navicula lanceolata", "N. viridula", "N. cari". Cryptogamie: Algologie 1: 29-50.
- \_\_\_\_\_ & K. Krammer. 1987. Bacillariaceae, Epithemiaceae, Surirellaceae. Neue und wenig bekannte Taxa, neue Kombinationen und Synonyme, sowie nachtragliche Bemerkungen zu de Naviculaceen. Bibliotheca Diatomologica 15:1-269.
- \_\_\_\_\_ & M. Ruppel. 1980. Zur revision taxonomisch problematischer okologisch; jedoch wichtiger Sippen der Gattung "Achnanthes" Bory. Archiv f. Hydrobiologie, Suppl.60, Algological Studies 26:1-31.
- \_\_\_\_\_ & Reimer Simonsen. 1978. A taxonomic revision of the Nitzschiae lanceolatae Grunow. 2. European and related Extra-european fresh water and brackish water taxa. *Bacillaria* 1:11-111.
- Moss, Maurice O. & John R. Carter. 1982. The resurrection of "Achnanthes rostrata" Ostrup. *Bacillaria* 5:157-164.
- Patrick R. & C.W. Reimer. 1966. Freshwater diatoms of the United States, Vol. I. Acad. Nat. Sci. Phila. Monograph No.13. 688 pp.
- \_\_\_\_\_. 1975. The diatoms of the United States. Vol. II. Acad. Nat. Sci. Phil. , Monograph No.13. 213 pp.
- Van Landingham, Sam L. 1964-1979. Catalogue of the fossil and recent genera and species of diatoms and their synonyms. (A revision of F.W. Mills, "An index to the genus and species of the Diatomaceae and their synonyms."). Parts I-VIII. Verlag von J. Cramer, Weinheim, Germany.
- Werff, A. Van der 1953. A new method of concentrating and cleaning diatoms and other organisms. *Verh. Int. Verein Theoret. und Ang. Limnol.* 12:276-277.
- Williams, D.M. 1985. Morphology, taxonomy and inter-relationships of the ribbed araphid diatoms from the genus "Diatoma" and "Meridion" (Diatomaceae:Bacillariophyta). *Bibliotheca Diatomologica* 8:5-228 + 27 plates.

## KEY TO PLATES

## Additions to Published Reports of Diatoms from Virginia Fresh Waters

PLATE	TAXON NAME
1-1	<i>Achnanthes exigua</i> Grun.
1-2	<i>A. hungarica</i> (Grun.) Grun.
1-3	<i>A. pinnata</i> Hust.
1-4	<i>Caloneis bacillaris</i> (Greg.) Cleve
1-5	<i>C. limosa</i> (Kutz.) Patr.
1-6	<i>Cymbella cuspidata</i> Kutz.
1-7	<i>C. minuta</i> var. <i>silesiaca</i> (Bleisch ex Rabh.) Reim.
1-8	<i>C. naviculiformis</i> Auersw.ex Heib.
1-9	<i>Eunotia formica</i> Ehr.
1-10	<i>E. lunaris</i> (Ehr.) Breb.
1-11	<i>E. monodon</i> Ehr.
1-12	<i>E. tautoniensis</i> Hust. ex Patr.
1-13	<i>Fragilaria construens</i> var. <i>venter</i> (Ehr.) Grun.
1-14	<i>F. pinnata</i> var. <i>lancettula</i> (Schum.) Hust.
1-15	<i>Gomphonema acuminatum</i> var. <i>clavus</i> (Breb.)Grun.
1-16	<i>G. angustatum</i> var. <i>intermedia</i> Grun.
1-17	<i>G. angustatum</i> var. <i>sarcophagus</i> (Grev.) Grun.
1-18	<i>G. apicatum</i> Ehr.
1-19	<i>G. clevei</i> Fricke
2-1	<i>G. gibba</i> Wallace
2-2	<i>G. lanceolatum</i> Ehr.
2-3	<i>G. lanceolatum</i> Ehr. f. <i>turis</i> (Ehr. c.p.) Hust.
2-4	<i>G. montanum</i> var. <i>subclavatum</i> Grun.
2-5	<i>G. puiggarianum</i> var. <i>aequatorialis</i> Cl.
2-6	<i>G. subclavatum</i> var. <i>commutatum</i> (Grun.) A.Mayer
2-7	<i>Melosira distans</i> var. <i>alpigena</i> Grun.
2-8	<i>M. islandica</i> O. Mull.
2-9	<i>Meridion circulare</i> var. <i>constrictum</i> (Ralfs.) V. H.
2-10	<i>Navicula anglica</i> var. <i>subsalsa</i> (Grun.) Cl.
2-11	<i>N. elginensis</i> var. <i>neglecta</i> (Krasske) Patr.
2-12	<i>N. exigua</i> var. <i>capitata</i> Patr.
2-13	<i>N. gottlandica</i> Grun.
2-14	<i>N. hustedtii</i> Krasske
2-15	<i>N. minima</i> Grun.
2-16	<i>N. mobilensis</i> var. <i>minor</i> Patr.
2-17	<i>N. mutica</i> f. <i>goeppertiana</i> (Bleisch.) Grun.
2-18	<i>N. mutica</i> f. <i>intermedia</i> (Hust.) Hust.
2-19	<i>N. peguana</i> (Grun.) Hust.
2-20	<i>N. pupula</i> var. <i>elliptica</i> Hust.



- 2-21 *N. radiosa* var. *parva* Wallace  
2-22 *N. seminulum* Grun.  
2-23 *N. seminulum* Grun. var. *hustedtii* Patr.  
2-24 *Neidium bisulcatum* var. *baicalensis* (Skv. & Meyer) Reim.
- 3-1 *N. gracile* f. *aequale* Hust.  
3-2 *N. hankensis* Skv.  
3-3 *N. herrmannii* Hust.  
3-4 *Nitzschia amphibioides* Hust.  
3-5 *N. bacata* Hust.  
3-6 *N. bremensis* Hust.  
3-7 *N. capitelata* Hust.  
3-8 *N. communis* Rabh.  
3-9 *N. denticula* Grun.  
3-10 *N. epithemoides* Grun.  
3-11 *N. frustulum* (Kutz.) Grun.  
3-12 *N. gracilis* Hantzsch  
3-13 *N. ignorata* Krasske  
3-14 *N. microcephala* Grun.  
3-15 *N. montanestrus* Camburn  
3-16 *N. recta* Hantz.  
3-17 *N. sinuata* var. *tabellaria* Grun.  
3-18 *N. tryblionella* var. *victoriae* Grun. (Grun.)  
3-19 *Pinnularia acrosphaeria* W.Sm.  
3-20 *P. braunii* var. *amphicephala* (A. Mayer) Hust.
- 4-1 *P. maior* var. *linearis* Cl.  
4-2 *P. mesogongyla* Ehr.  
4-3 *P. nodosa* (Ehr.) W.Sm.  
4-4 *P. subcapitata* var. *paucistriata*  
4-5 *P. viridis* var. *commutata* (Grun.) Cl.  
4-6 *Rhopalodia gibberula* var. *vanheurckii* O. Mull.  
4-7 *Stauroneis anceps* f. *gracilis* Rabh.  
4-8 *S. smithii* Grun.  
4-9 *Surirella ovata* var. *pinnata* W.Sm.  
4-10 *Synedra incisa* (Boyer)  
4-11 *Thalassiosira fluviatilis* Hust.

PLATE 1

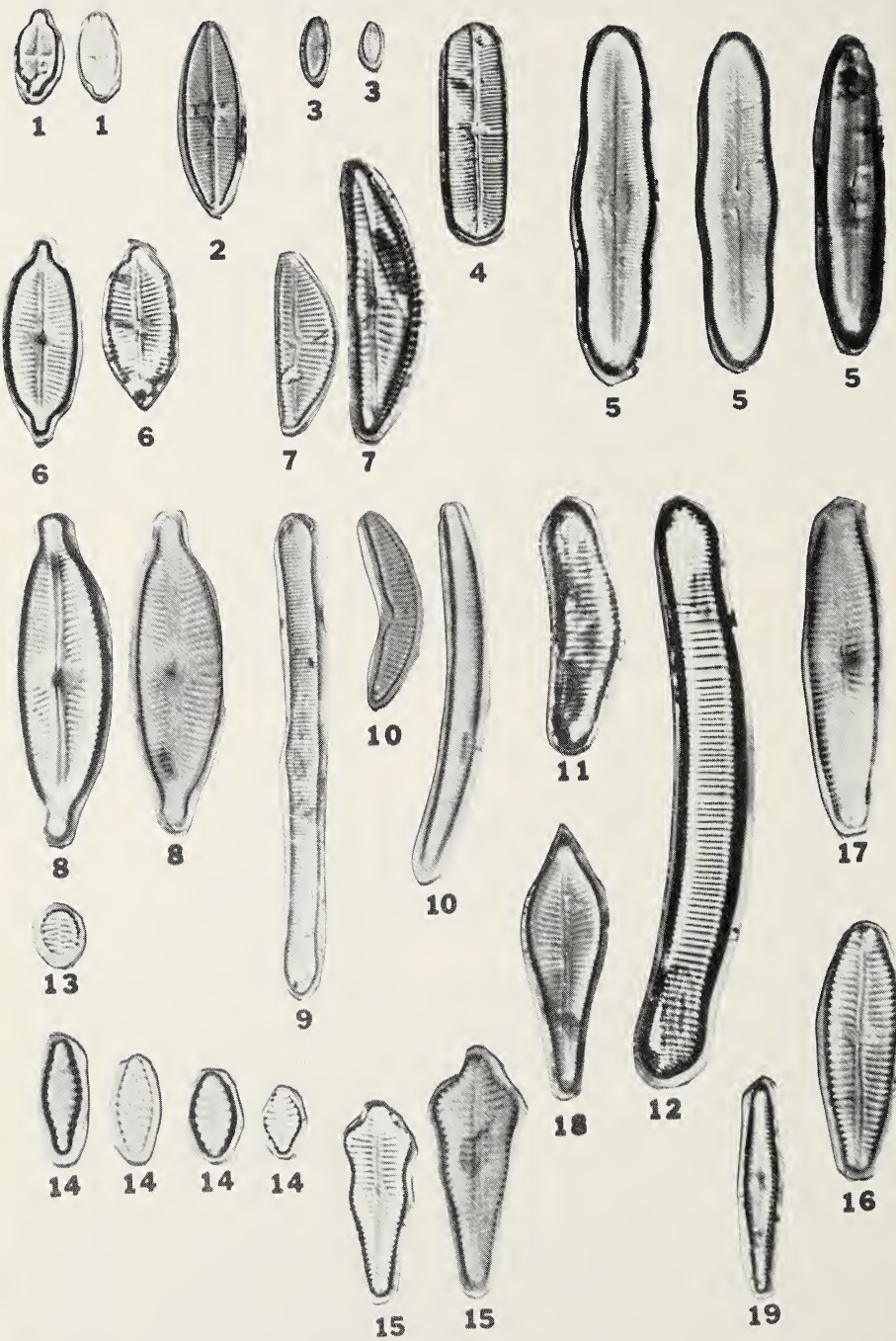


PLATE 2

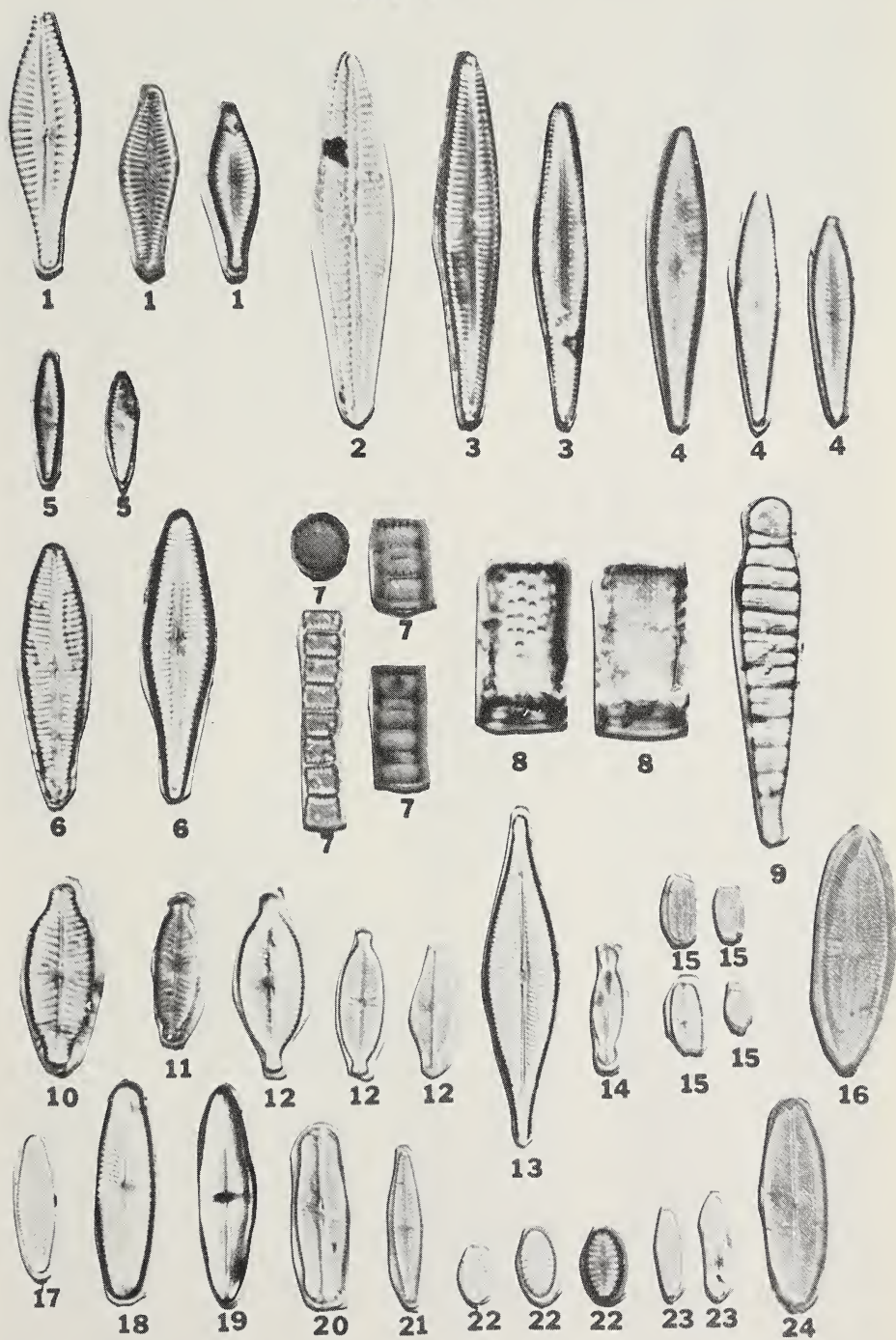




PLATE 3

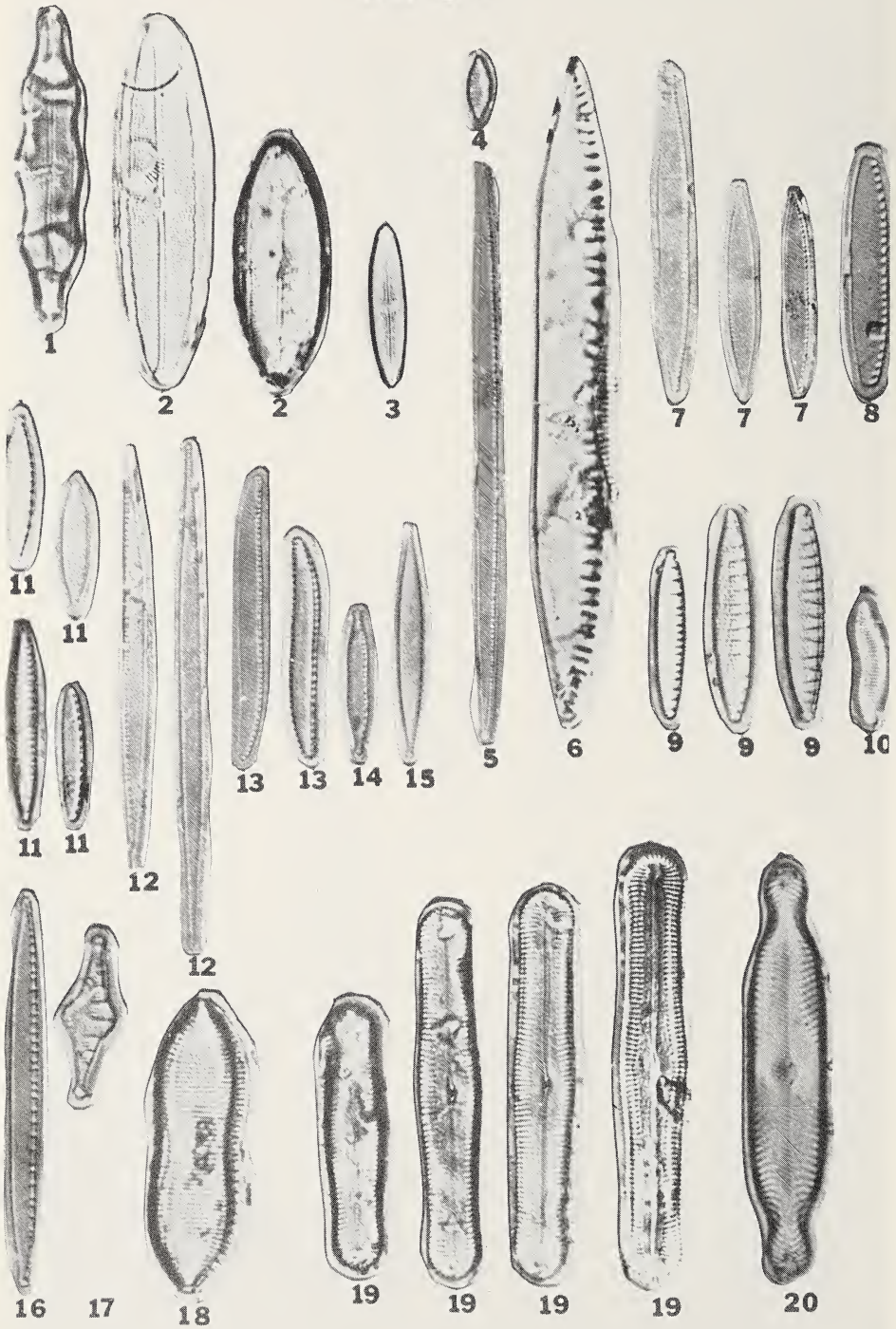
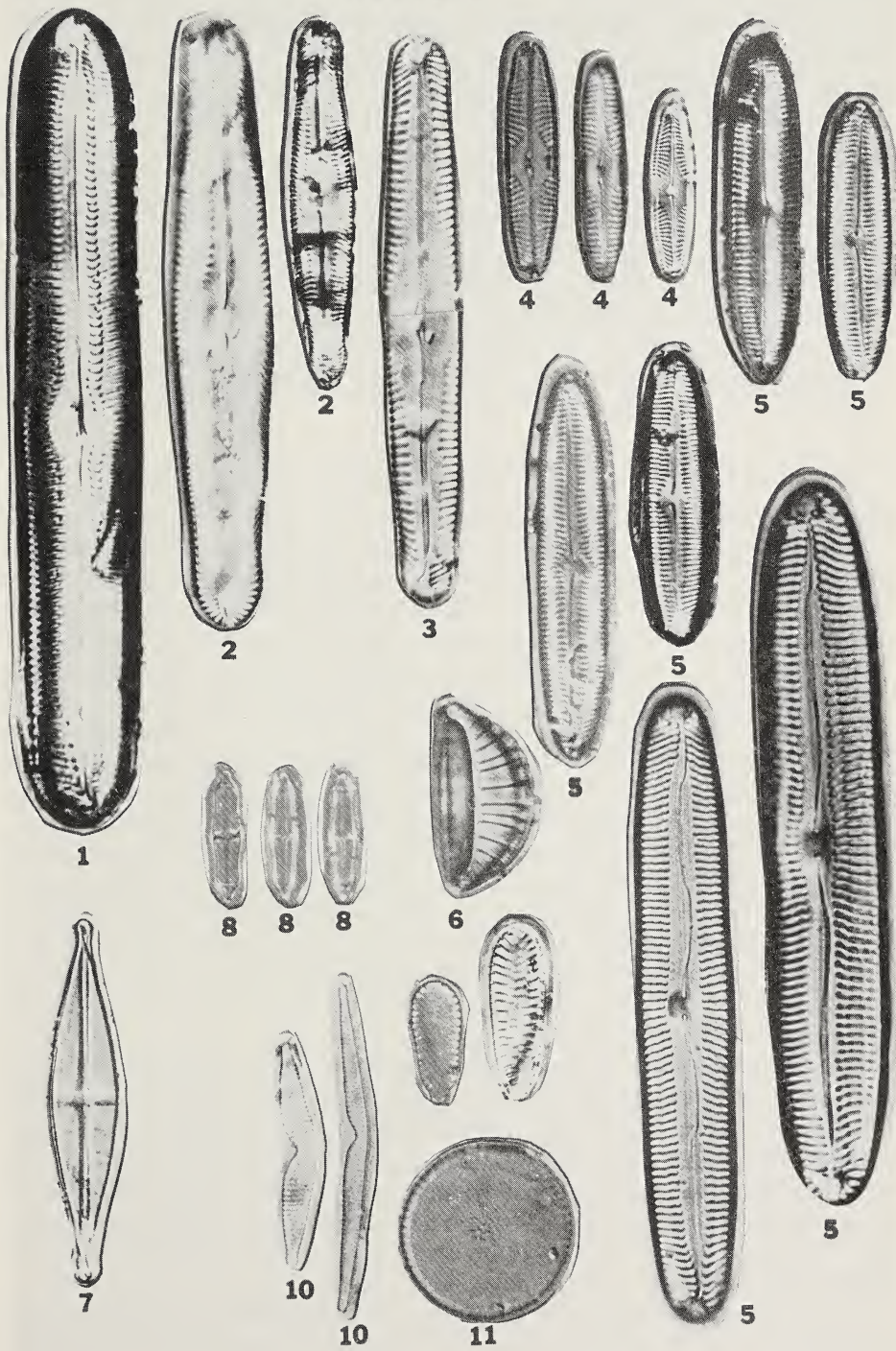


PLATE 4





## Behavior of the *Chymomyza aldrichii* species group (Diptera: Drosophilidae) in Virginia's Allegheny Mountains

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### ABSTRACT

*Chymomyza procnemoides* and *C. aldrichii* are members of the *aldrichii* lineage established by Okada (1976) from morphology. Both are sympatric in Virginia's Allegheny Mountains where males display together on damaged wood. Behavioral studies indicate significant differences between the two species in mating behavior, duration of copulation and mode of male aggression. This suggests either a continuing divergence promoted by sympatry or a need to reappraise species-groups, incorporating work on behavior.

### INTRODUCTION

In the family Drosophilidae, males in the genus *Chymomyza* (Wheeler, 1952) and among the Hawaiian *Drosophila* are characterized as aggressive. Behavior among the latter has been the subject of extensive investigations (Spieth, 1966, 1968, 1974a,b, 1978, 1981a,b; Spieth in Carson *et al.*, 1970; Spieth and Heed, 1972; Spieth and Ringo, 1983; Spieth in Ehrman, 1978). Behavior in the genus *Chymomyza* has received little attention despite long being used to characterize its members. Sturtevant (1916) noted their wing-waving behavior. Wheeler (1952) described *C. amoena* males as boxing with their forelegs. This came to typify the genus, as did assault-type mating although Spieth (1952) found differences in mating behavior between *C. amoena* and *C. procnemis*. Band (1988a) found that *C. amoena* females elevated the abdomen to continue feeding and repulse courting males. This species has become a widely distributed fruit-breeder in Virginia Band (1988b).

Okada (1976) divided the genus *Chymomyza* into 5 species-groups on the basis of morphological traits: *obscura*, *procnemis*, *fuscimana*, *costata*, and *aldrichii*. The latter contains both *C. aldrichii* and *C. procnemoides*, described by Sturtevant (1916) and Wheeler (1952) respectively from western populations. Grimaldi (1986), studying a *C. aldrichii* lineage in South America, discovered that one species, *C. exophthalma*, slashed at opponents with the forelegs; the radiation contains broad-headed species.

Spieth (1952), from a study of continental *Drosophila*, stressed behavioral similarities within lineages. This was also observed among the Hawaiian *Drosophila* (Spieth, 1966, 1978, 1981a,b). Comparisons included modes of male aggression as curling and slashing, headbutting, mating duration and mating behavior. Differences in mating behavior observed in *C. amoena* (Wheeler, 1947, 1952; Spieth, 1952) and *C. procnemis* (Wheeler, 1947; Spieth, 1952) parallel their placement in different species-groups, *fuscimana* and *procnemis* respectively (Okada, 1976).

In Virginia's Allegheny Mountains, both *C. procnemoides* and *C. aldrichii* may be found on the same fresh damaged tree during the second half of July (Band,



1988c). Studies in 1989 enabled comparison of mode of aggression and mating behavior in these two sympatric species.

#### MATERIALS AND METHODS

Sympatric occurrence: In 1986 12 *C. procnemoides* males, 7 *C. procnemoides* females, 10 *C. aldrichii* males and 1 *C. aldrichii* female were collected on wild cherry, *Prunus* sp. In 1987 6 *C. procnemoides* males, 2 *C. procnemoides* females, 9 *C. aldrichii* males and 4 *C. aldrichii* females were collected on striped maple, *Acer pensylvanicum*. Both collections were made in the second half of July and established sympatry of the two species (Band, 1988c).

In 1988, 7 *C. procnemoides* males, 3 *C. procnemoides* females and 1 *C. aldrichii* male were captured on a damaged striped maple. Collections were in early July. Flies were captured in 25mm x 95 mm shell vials, stoppered with cotton. Specimens were immediately transported to the laboratory and gently etherized for identification. Wheeler's (1952) key is used to avoid difficulties arising from a color polymorphism that has been found to occur in these two species in this area (Band, 1988c).

In 1989 among the *Chymomyza* captured were 8 *C. procnemoides* males, 7 *C. procnemoides* females, 3 *C. aldrichii* males and 2 *C. aldrichii* females. The capture site was a damaged northern red oak, *Quercus rubra*. Collections were during the second half of July, and flies were transported to the laboratory within a half-hour of collection. All collections reported here were on damaged trees at approximately the 3800 foot (approx. 1200 meters) level.

Laboratory studies: In 1988 due to the shortage of *C. aldrichii* in early July, only mode of aggression and mating behavior could be studied in *C. procnemoides*. Among the cultures set was one containing 3 *C. procnemoides* males, one containing a female and two males, a mating pair captured on the underneath side of the lek tree; later another single pair was constructed from a male and a female captured separately. Cultures set in 1989 included 2 single *C. procnemoides* pairs, one with 5 males, and one with 3 females. After several days' observations on single sex cultures, they were combined, with losses. *C. aldrichii* cultures included two single pairs. However, the female in one of the single pair cultures died, so the male was added to the surviving culture; males were of unequal size. Later the surviving *C. aldrichii* female became trapped in the muslin cap, reducing the culture to 2 *C. aldrichii* males. The third *C. aldrichii* male, after capture, was added to the two males.

In both years, pint-sized glass canning jars capped with muslin were used for cultures. Medium was made at Michigan State University, poured into plastic food dishes cut from 9 oz cups, transported in a picnic cooler to Mt. Lake Biological Station and refrigerated until needed. Medium used for *C. procnemoides* was *C. amoena* medium (Band, 1988a). For *C. aldrichii* instant food (Carolina Biological Supply) was used, and prepared as needed. A Bausch and Lomb dissecting microscope equipped with 10x oculars was used for species identification and as an aid for some observations.

Observations were also made at the damaged tree each year to compare laboratory and natural site work.

The extensive 2-year (1988, 1989) behavioral observations on *C. procnemoides* have been reported in detail elsewhere (Band, 1990). Here we include only comparative information between the two sympatric species in the *C. aldrichii* group.

### RESULTS

*Chymomyza procnemoides*: Males of this species were observed to butt heads. Four episodes were recorded among the 3 males in the all male culture in 1988. One occurrence was seen at the lek site. One episode of headbutting occurred in the all male culture in 1989 and later among males in the small population of *C. procnemoides* after single sex cultures of males and females were combined. In the second half of July (1989) behavioral aggression among males seemed less intense than in the first half of July (1988). In headbutting, males draw the forelegs up to the head so that both head and forelegs are involved in the "battering ram" action. The head also appears broader.

Abdominal curling, that is curving the abdomen sidewise, was witnessed in the all male culture in 1988 and also in a single pair culture. However flies in neither single sex culture in 1989 performed this maneuver. In 1988 this action was not followed by an attack using the concave side against an opponent, as described by Spieth (1966) among Hawaiian *Drosophila*. Males have no method of countersignaling; however, as soon as a male lunges onto another male, the two break up.

Spieth (1966) has remarked it is difficult among Hawaiian *Drosophila* to determine how a female signals acceptance of a male. *Chymomyza procnemoides* females have no trouble rejecting a male via vigorous shaking. Elevating the tip of the abdomen also blocks the male. Rejection can quickly turn to acceptance. Two matings, including a drop-capture, suggest that the female extends her abdomen as the male lunges forward, genitalia curled under. He lifts her wings with his head as he mounts and she later spreads them to an angle of about 40-to-60°. The male's wings remain folded over his body. He securely grasps her abdomen with the femoral spines on his forelegs; then shaking will not dislodge him.

Mating typically is lengthy, over a half hour. Both sexes mate repeatedly. The female with the two unequal sized males mated with both, seven times with the large male and five times with the smaller male over a three day period. In early July 1988 neither the female with two males nor the female of the captured mating pair mated the first day under laboratory conditions. Confirming female receptivity at the lek site, a vial containing two *C. procnemoides* males and two *C. procnemoides* females captured separately became two mating pairs before they could be transferred to cultures in the laboratory in 1989. Females captured in the early part of July (1988) mated more than once a day; females captured in the second part of July (1989) averaged one mating a day. Duration of mating was timed only over the first four days after cultures were set up. Mating termination is abrupt; the male simply backs off. This may be preceded by the female's kicking one to a few minutes beforehand.

*Chymomyza procnemoides* pairs fly *en copula*. One pair was observed to land and take off repeatedly as they flew around the culture bottle in 1988. This was confirmed by the latter single pair set up in 1988.



One female in 1988 produced 5 eggs which hatched; larvae reached pupal stage. Despite the multiple matings, females in 1989 did not produce eggs.

*Chymomyza aldrichii*: Most encounters between males involved foreleg touching only. However, in serious aggressive bouts, males lock forelegs. Five episodes confirmed that this is the mode of aggression in this species. However, foreleg interlocking did not occur until the third male was added with the other two unequal sized males. This suggests that only equal sized males within a species fight.

Males are more sexually aggressive than are *C. procnemoides* males. There is much chasing, abdominal grabbing, and mounting one another, after which pairs break apart. Even after the demise of the female, males never seemed to learn there was no female present. As with *C. procnemoides*, males have no method of countersignaling; wing fluttering (Spieth, 1952) is part of the normal wing-waving activity in this species as in *C. procnemoides*.

A *Chymomyza aldrichii* female has no trouble rejecting a 'courting' male by shaking him off. She may also elevate her abdomen slightly. This is by no means an extreme elevation as observed in *C. amoena* for which a photograph is included in Band (1988c).

A female signals acceptance by spreading her wings 90° as the male lifts her abdomen with his forelegs, and climbs onto it. During mating, the female relaxes her wings to an angle of 50-to-60°. His also remain parted. Duration of mating, about 13 minutes, is significantly shorter than for *C. procnemoides*. Both sexes mate repeatedly. Mating termination is abrupt, as in *C. procnemoides*. Behaviors for both species are summarized in Table 1. Additionally, the modes of male aggression observed to date among chymomyzids are listed in Table 2.

Lek sites: One episode of headbutting between *C. procnemoides* males occurred at the lek site, a damaged striped maple, in 1988. A mating pair was also captured on the underside of the same tree.

Matings were also witnessed at the lek site in 1989, a damaged northern red oak. The presence of *C. amoena*, which has banded wings, confirmed that males chase and lunge onto other species.

Non *Chymomyza* captured at the lek site in 1989 included *Scaptomyza* (3 males, 2 females) and *Drosophila* (1 *D. affinis* male).

#### DISCUSSION

The described modes of male aggression among chymomyzids have now increased to four. Three of the species belong to the *C. aldrichii* group (Okada, 1976): *exophthalma* (Grimaldi, 1986), *procnemoides* and *aldrichii* (Okada, 1976). Ironically of the two sympatric species in Virginia's Allegheny Mountains, it is *C. procnemoides* which shows headbutting and a broaden head, not *C. aldrichii*. Although no headbutting was recorded among broad-headed species in the South American *C. aldrichii* radiation, Grimaldi (1986) is correct to conclude that episodes have not yet been seen. Multiple factors, including size of combattants and age, appear to affect male aggressiveness. In the case of *C. procnemoides* both level of aggression and mating activity seemed higher earlier in July than later in the month. Ringo (1978) found contact aggression to vary with time in one Hawaiian species, *D. grimshawi*. Jousting and curling were largely absent among males in the first two weeks, then increased in frequency to a maximum at 3 to 4



TABLE 1. Comparison of mating behavior of sympatrically occurring *Chymomyza procnemoides* and *C. aldrichii* in Virginia's Allegheny Mountains.

Characteristic	<i>C. procnemoides</i>	<i>C. aldrichii</i>
average mating duration	31.9 $\pm$ 1.9 min.	12.8 $\pm$ 1.9 min.
no. matings timed	28	8
female's wings parted	yes	yes
fly and mate	yes	?
repeat matings	yes	yes
female acceptance signal	abdomen extended	wings spread to 90°
mode of male aggression	headbutting	foreleg locking
mounting	lunge	climbs onto abdomen
drop-capture	yes	not observed
curl abdomen	yes	not observed

mating duration, *C. procnemoides* versus *C. aldrichii*:  $F_{1,34} = 5.37$ ;  $P < 0.05$

weeks of age. However, of the two behaviors in *D. grimshawi*, jousting was common and curling was rare.

Mating behavior likewise differs between the two sympatric *Chymomyza* species. Whereas both females' wings are parted during mating, a *C. aldrichii* female spreads hers as an acceptance signal; the *C. procnemoides* male lifts the *C. procnemoides* female's wings in mounting and then she parts them. However males of both species maintain a secure grasp of the female's abdomen with the spines of the forefemora. This differs from the described mating behaviors of *C. procnemis* and *C. amoena* (Spieth, 1952). The mounting *C. procnemis* male parts the *C. procnemis* female's wings with his head, but grasps them with his forefemora; a *C. amoena* male does not part a *C. amoena* female's wings when mounting.

Of the two species, *C. aldrichii* is the more sexually aggressive. This was evidenced in the all male cultures and cultures of males and females. Where cultures contained unequal sized males plus a female, the smaller *C. aldrichii* male was at a clear disadvantage to the larger male; he mated only once. The smaller *C. procnemoides* male mated almost as frequently as the larger male.

Mating pairs of *C. procnemoides* have been observed to fly and continue to mate. Presumably mating pairs of *C. aldrichii* can do this too, though this was not observed during laboratory observations in 1989. Females as well as males of both species also mate repeatedly, in contrast especially to *C. amoena* (Wheeler, 1947; Band, 1990). *Drosophila pegasa* in the *repleta* group manifests behavior similar to *C. procnemoides*; a male will remain mounted for hours, with matings occurring intermittently. The species has reverted to the assault-type mating characteristic of *Chymomyza* (Wasserman *et al.*, 1971).

Duration of mating time differs significantly between the two sympatric *Chymomyza* species. Although species within the same lineage typically have similar mating durations, Spieth and Ringo (1983) list exceptions in the *willistoni*, *melanogaster*, and *obscura* groups, all of which belong to the *Sophophoran* subgenus

TABLE 2. Modes of male aggression in the genus *Chymomyza*

Type	<i>Chymomyza</i> species	Reference
boxing, sparring	<i>C. amoena</i>	Wheeler (1952)
slashing	<i>C. exophthalma</i>	Grimaldi (1986)
head-butting	<i>C. procnemoides</i>	Band (1990 & here)
foreleg locking	<i>C. aldrichii</i>	Band (here)

and share chromosomal affinities with *Chymomyza* (Clayton and Guest, 1986). Jacobs (1978) demonstrated territoriality in *D. melanogaster* males; Taylor and Kekic (1988) found male aggregation in this same species. Both are aspects of lek behavior.

Although lineages were grouped according to morphological characteristics (Okada, 1976) and a body color polymorphism limits the usefulness of his key in the Mt. Lake area, behavioral comparisons have been too few among *Chymomyza* species to argue that differences in mode of male aggression or duration of mating time cannot vary within lineages. In Japan *C. fuscimana* and *C. distincta* occur sympatrically (Watabe, 1985), and are included with *C. amoena* in the *fuscimana* lineage (Okada, 1976). Sympatry at a lek site would in fact favor divergence, not parallelism or convergence.

Observed similarities and differences between the two species in the *aldrichii* lineage and species in other lineages demonstrate that mode of aggression and mating behavior enable interspecific behavioral divergence to accompany morphological divergence within the simplicity of assault-type mating in the genus *Chymomyza*. It also indicates that sympatry among lek-sharing chymomyzid species may provide a test of sexual selection to drive genetic changes as hypothesized by Spieth and Ringo (1983) and earlier (Spieth, 1974b; Ringo, 1977). *Chymomyza aldrichii* was captured along with other *Chymomyza* in the west (Wheeler, 1952); therefore an eastern sympatric situation is non-unique.

It also raises the question if differences in mating behavior exist among *Scaptomyza* species. These species also have simple assault-type mating, and may also on occasion share lek sites with *Chymomyza*.

#### ACKNOWLEDGEMENTS

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#### LITERATURE CITED

- Band, H. T. 1988a. Host shifts of *Chymomyza amoena* (Diptera: Drosophilidae). Amer. Midl. Nat. 120: 163-182.  
 \_\_\_\_\_. 1988b. *Chymomyza amoena* (Diptera: Drosophilidae) in Virginia. Va. J. Sci. 39: 378-392.



- \_\_\_\_\_. 1988c. Behavior and taxonomy of a chymomyzid fly (*Chymomyza amoena*). Intern. J. Comp. Psychol. 2: 3-26.
- \_\_\_\_\_. 1990. Comparison of mating and male aggressive behavior in two forest *Chymomyza* (Diptera: Drosophilidae). Inter. J. Comp. Psychol. 3 (submitted).
- Carson, H. L., D. E. Hardy, H. T. Spieth, and W. S. Stone. 1970. The evolutionary biology of the Hawaiian Drosophilidae. pp. 437-543 in M. K. Hecht, and W. C. Steere (eds.). Essays in Evolutionary Genetics in Honor of Theodosius Dobzhansky. Appleton-Century-Croft, New York.
- Clayton, F. C. and W. C. Guest. 1986. Overview of chromosomal evolution in the family Drosophilidae. pp. 1-38 in M. Ashburner, H. L. Carson and J. N. Thompson, Jr. (eds.). Genetics and Biology of *Drosophila*. Vol. 3e. Academic, London.
- Ehrman, L. 1978. Sexual behavior. pp. 127-180 in M. Ashburner and T. F. R. Wright (eds.). Genetics and Biology of *Drosophila*. Vol. 2b. Academic, London.
- Grimaldi, D. 1986. The *Chymomyza aldrichii* species-group (Diptera: Drosophilidae): relationships, new neotropical species and the evolution of some sexual traits. J. New York Entomol. Soc. 94: 342-371.
- Jacobs, M. E. 1978. The influence of beta-alanine on mating and territorialism in *Drosophila melanogaster*. Behav. Genet. 8: 487-502.
- Okada, T. 1976. Subdivision of the genus *Chymomyza* Czeryny (Diptera: Drosophilidae), with description of three new species. Kontyu, Tokyo 44: 496-511.
- Ringo, J. M. 1977. Why 300 species of Hawaiian *Drosophila*? The sexual selection hypothesis. Evolution 31: 695-696.
- \_\_\_\_\_. 1978. The development of behavior in *Drosophila*. pp. 63-80 in G. M. Burghart and M. Bekoff (eds.). The Development of Behavior: Comparative and Evolutionary Aspects. Garland STPM, New York.
- Spieth, H. T. 1952. Mating behavior within the genus *Drosophila* (Diptera). Bull. Amer. Museum Nat. Hist. 99: 395-474.
- \_\_\_\_\_. 1966. Courtship behavior of the endemic Hawaiian *Drosophila*. Univ. Texas Publ. No. 6615: 245-313.
- \_\_\_\_\_. 1968. Evolutionary implications of sexual behavior in *Drosophila*. Evol. Biol. 9: 157-193.
- \_\_\_\_\_. 1974a. Courtship behavior in *Drosophila*. Ann. Rev. Entomol. 19: 385-405.
- \_\_\_\_\_. 1974b. Mating behavior and evolution of the Hawaiian *Drosophila*. pp. 94-101 in M. J. D. White (ed.). Genetic Mechanisms of Speciation in Insects. Reidel, Dordrecht.
- \_\_\_\_\_. 1978. Courtship patterns and evolution of the *Drosophila adiantula* and *planitibia* species subgroups. Evolution 32: 435-451.
- \_\_\_\_\_. 1981a. *Drosophila heteroneura* and *D. silvestris*: head shape, behavior and evolution. Evolution 35: 921-930.
- \_\_\_\_\_. 1981b. Courtship behavior and evolutionary status of the Hawaiian *Drosophila primaeva* Hardy and Kaneshiro. Evolution 35: 815-817.
- Spieth, H. T. and W. B. Heed. 1972. Experimental systematics and ecology of *Drosophila*. Ann. Rev. Ecol. Syst. 3: 269-288.



- Spieth, H. T. and J. M. Ringo. 1983. Mating behavior and sexual isolation in *Drosophila*. pp. 223-284 in M. Ashburner, H. L. Carson and J. N. Thompson, jr. (eds.) Genetics and Biology of *Drosophila*. Vol. 3c. Academic, London.
- Sturtevant, A. W. 1916. Notes on North American Drosophilidae with descriptions of twenty-three new species. *Ann. Entomol. Soc. Amer.* 9: 323-343.
- Taylor, C. E. and V. Kekic. 1988. Sexual selection in a natural population of *Drosophila melanogaster*. *Evolution* 42: 197-199.
- Wasserman, M., J. L. Heller and J. Zambek. 1971. Male-determined sexual discrimination in the species, *Drosophila pegasa*. *Amer. Midl. Nat.* 86: 231-235.
- Watabe, M. 1985. A preliminary note on the drosophilid flies collected at timberyards in Northern Japan. *Dros. Inf. Serv.* 61: 183-184.
- Wheeler, M. R. 1947. The insemination reaction in intraspecific matings of *Drosophila*. Univ. Texas Publ. No. 4770: 78-115.
- \_\_\_\_\_. 1952. The Drosophilidae of the Nearctic region exclusive of the genus *Drosophila*. Studies in the Genetics of *Drosophila* VII. Univ. Texas Publ. No. 5204: 162-218.

## JEFFRESS RESEARCH GRANT AWARDS

The Allocations Committee of the Thomas F. and Kate Miller Jeffress Memorial Trust has announced the award of Jeffress Research Grants to the institutions listed below to support the research of the investigator whose name is given. The Jeffress Trust, established in 1981 under the will of Robert M. Jeffress, a business executive and philanthropist of Richmond, supports research in chemical, medical and other natural sciences through grants to non-profit research and educational institutions in the Commonwealth of Virginia. The Jeffress Research Grants being announced here have been awarded in 1989.

The Jeffress Memorial Trust is administered by Sovran Bank, N.A. Additional information about the program of the Trust may be obtained by writing to: Advisor, Thomas F. and Kate Miller Jeffress Memorial Trust, Trust Department, Sovran Bank, N.A., P. O. Box 26903, Richmond, VA 23261.

- Paul F. Aravich, Eastern Virginia Medical School. The Role of Insulin in Recovery of Function in the Central Nervous System. \$27,923 (one year).
- Stephen J. Beebe, Eastern Virginia Medical School. Analysis of Three Catalytic Subunit Isozymes of the cAMP Dependent Protein Kinase. \$39,960 (two years)-
- Robert A. Bloodgood, University of Virginia. Transmembrane Signaling in the *Chlamydomonas Flagellum*, \$28,791 (two years).
- Jay C. Brown, University of Virginia. Localization of Proteins in the Capsid of Herpes Simplex Virus. \$30,750 (two years).
- Steven S. Oesjardins, Washington and Lee University. A Theoretical Model of Lipid Solubility. \$12,017 (two years).
- Harry C. Dorn, Virginia Polytechnic Institute and State University. (15) N NMR Signal Enhancement Utilizing Flow Transfer Dynamic Nuclear Polarization. \$21,350 (one year).
- M. G. Finn, University of Virginia. Enhanced Reactivity and Asymmetric Synthesis with Metal-Substituted Fischer Carbene Complexes. \$47,600 (one year).
- David A. Gewirtz, Virginia Commonwealth University. Site-Specific DNA Damage Induced by Antineoplastic Drugs in the Hepatoma Cell. \$37,855 (two years)-
- Emma W. Goldman, University of Richmond. Preparation and Reactivity of Iron Silane Complexes. \$8,795 (one year renewal).
- Gary J. Gorbisky, University of Virginia. Microtubule-binding Proteins of the Sea Urchin Kinetochore. \$33,000 (two years).
- Michael R. Gretz, George Mason University. Plant Growth Adaptations to Saline Environments: Apoplastic Contributions to Halotolerance. \$19,225 (two years).
- Jack L. Haar, Virginia Commonwealth University. Isolation of thymic factors for bone marrow pre-T Lymphocytes.. \$17,535 (one year).

- Gina L. Hoatson, The College of William and Mary. Deuteron Magnetic Resonance of Liquid Crystals and Binary Mixtures. \$17,000 (one year renewal).
- W. Gary Hollis, Jr., The College of William and Mary. The Use of Chiral Boronate Esters in Asymmetric Diels-Alder Cycloadditions. \$42,750 (three years).
- Michael P. Holsapple, Virginia Commonwealth University. Activation of B-lymphocytes by 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD): Comparison to Interleukin 4 (IL4). \$69,855 (two years).
- Thomas Hudlicky, Virginia Polytechnic Institute and State University. Bacterial oxidation of Arenes and Other Microbial Transformations in Enantioselective Synthesis. \$58,421 (three years).
- Shaheen M. Islam, University of Richmond. X-Ray Absorption Fine Structure Study of a Semiconductor Alloy. \$24,435 (two years).
- Norbert E. Kaminski, Virginia Commonwealth University. Immunomodulation by Serum Amyloid A protein. \$30,160 (one year).
- Muriel Lederman, Virginia Polytechnic Institute and State University. Testing a Kinetic Hairpin Transfer Model of Parvovirus DNA Replication. \$11,200 (one year).
- Ting-Kuo Lee, Virginia Polytechnic Institute and State University. Theoretical Study of High Temperature Superconductors. \$19,785 (two years).
- Joseph B. Liberti, Virginia Commonwealth University. Endocrine Regulation of Immune Response in Aged Rats. \$29,550 (one year).
- G. Paul Matherne, Jr., University of Virginia. Ontogeny of Coronary Vascular Control. \$47,085 (three years).
- Kathleen L. McCoy, Virginia Commonwealth University. Role of Antigen-Presenting Cells in Helper CD4+ T Cell Activation. \$44,712 (three years).
- Donald C. Meyer, Eastern Virginia Medical School. Location and Serotonergic Control of the LHRH Pulse Generator. \$37,829 (two years).
- George Moxley, Virginia Commonwealth University. Immunoglobulin Kappa in Rheumatoid Arthritis. \$16,667 (one year).
- John E. Nestler, Virginia Commonwealth University. Diabetes and Pregnancy: An Evaluation of the Effects of Insulin and IGF-1 on Human Steroidogenesis. \$48,600 (three years).
- Pauline G. Newlon, Eastern Virginia Medical School. Septo-Hippocampal Interactions in Neural Plasticity. \$47,428 (two years).
- Sammye Newman, Virginia Commonwealth University. Identification and Analysis of Promoter Elements of the Mouse Myelin Basic Protein Gene. \$32,021 (two years).
- James K. Roche, University of Virginia. Immunobiology of Type-I Diabetes Mellitus: Characterization and Role of Antigens from Murine Pancreatic Beta Cell Lines. \$24,270 (one year).
- Guillermo G. Romero, University of Virginia. Studies on the Second Messengers of Insulin Action. \$30,791 (one year renewal).
- Suzanne M. Ruder, Virginia Commonwealth University. Tandem Ring Expansion - Intramolecular Wittig Reaction: A Route to a Variety of Antitumor Reagents. \$25,600 (two years).



- Sarah C. Rutan, Virginia Commonwealth University. Kinetic Studies in Heterogeneous Media. \$39,494 (two years).
- Robert F. Smith, George Mason University. Neurobehavioral effects of prenatal cocaine in the rat. \$18,750 (one year).
- Bruce N. Tedeschi and Francis J. Liuzzi, Eastern Virginia Medical School. Neuronal Growth Responses to PNS and CNS Environments - A Molecular Study. \$28,250 (one year).
- Ted S. Thomas, University of Virginia. The Role of SOG in Complement Inhibition. \$29,520 (one year).
- Duo-Hui Wang, Eastern Virginia Medical School. Microvascular changes in rat cremaster muscle during chronic decreases in blood flow. \$2,880 (one year).
- Joy L. Ware, Virginia Commonwealth University. Growth Regulatory Pathways in Human Prostatic Cancer. \$30,904 (two years),

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Clinch Valley College,  
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**Animal Population Biology**  
Stephen G. Tilley  
Smith College

**Workshop in Nature Photography**  
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John Danchy

**Workshop for Secondary School  
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(July 1-14)  
Jerry O. Wolff  
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**Second Term**  
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Bruce Grant  
College of William and Mary

**Experimental Biology of Fungi**  
Rytas Vilgalys  
Duke University

**Quantitative Methods in  
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## Roscoe Hughes Memorial Plaque Dedicated

*Text of the address given by President Michael Bass on August 11, 1989, during the dedication of the Roscoe Durall Hughes Memorial Plaque at the Science Museum of Virginia, Richmond, VA.*

Many members of the Virginia Academy of Science have shown an interest in the establishment of a scientific museum, since its beginning in 1924. A state museum was therefore started early - one of minerals, timber and natural history. It was located in the basement of the old Finance Building. The State Museum was described by an Academy member at a council meeting in 1963 as disgraceful. The need for an inspiring science museum for the Commonwealth of Virginia had been apparent for many years. A resolution was prepared on November 10, 1963 requesting that Governor Albertis Harrison appoint a committee to consider means for the short and long-range improvement of the State Museum and make recommendations for the scope and objectives of the Museum. In 1964, the General Assembly directed that a study be made.

Dr. Roscoe Hughes served on this Advisory Committee, appointed under the provision of the Senate Joint Resolution Bill No. 26. His time/effort given to the preparation of a final report reflected greatly his deep and devoted interest in the establishment of a new vision - the Virginia Science Museum, instead of improving the old concept in the basement of the Finance building.

During his Presidency of the VA Academy of Science in 1965-66, two outstanding events developed from Dr. Hughes' leadership.

1. He established the "Visiting Scientist Program" supported then by an NSF Grant which allowed some 60 days of visitations by qualified college Professors to high schools throughout the state of Virginia. This program continues today with the help of the State Department of Education.

2. During his term as President of the Academy, a resolution concerning a Virginia museum of science was developed. A special committee of three members from within the Academy Council, with President Hughes as the guiding master, printed the final draft on 4 May 1967. The then immediate Past President Hughes moved forward into adoption. From this date to the final approval of the General Assembly that created the Science Museum of Virginia in 1970, Dr. Hughes was everywhere seeking/securing support for this museum. It was most proper that he served as the first Chairman of the Board of Trustees as appointed by Governor Linwood Holton.

As President of the VA Academy of Science, I assure you that all members of the Academy are deeply interested in the growth of this Museum. We are proud of the many contributions past members have made to its creation and the maintaining of Roscoe's goals.

Roscoe Durall Hughes has honored us by having had this great, big vision of a Virginia science museum, the ability to develop, nurture and create it into existence. Especially, are we grateful to Roscoe for developing in each of us such a great feeling of accomplishment and pride in this our Virginia Science Museum.





Elizabeth Hughes with the plaque she unveiled in the memory of her husband, Dr. Roscoe D. Hughes.

*The following (reproduced by permission) is an excerpt from Basic Facts--Bulletin of the school of Basic Health Sciences, R. D. Hughes Memorial Issue. Basic Facts is published quarterly by the School of Basic Health Sciences, Virginia Commonwealth University, S. Gaylen Bradley, Ph.D., Dean, Patricia R. Ashlaw, Editor.*

### **Dr. Roscoe D. Hughes -- A Man of Vision**

On August 11, 1989, the Science Museum of Virginia dedicated a plaque in memory of Dr. Roscoe D. Hughes for his efforts to establish this unique museum. Because of his vision, and with the support of the Virginia Academy of Science, the State of Virginia embarked on a bold new venture to build one of the finest science museums in the nation. To fulfill this mandate, the Governor of Virginia, Albertis Harrison, formed an Advisory Committee in 1965 for the Encouragement of the Establishment of a Museum of Science. In 1968, Governor of Virginia, Mills Godwin, established the Science Museum Study Commission which led in 1970 to the Virginia State Senate Bill creating the Science Museum of Virginia. Dr. Hughes, the impetus for and strong supporter of this museum, was appointed to both the committee and the commission. He brought with him his rich professional background, enthusiasm and strong personal commitment. This establishment of a science museum was a cherished dream and one to which he gave a characteristically determined effort to bring into reality.

### **The Individual -- His Life and Research**

Born in Dupont, Georgia on March 1, 1903, Dr. Hughes attended elementary and secondary school in Valdosta. In 1927 he graduated from the United States Naval Academy. While serving in the Navy after leaving Annapolis, he became interested in the genetic studies of Charles Davenport at Carnegie Institute. Eventually he left active naval duty to pursue this interest. The final deciding factor was "an overwhelming positive reaction to science rather than a negative reaction to the Navy," he wrote to W. F. Rudd, Dean of the pharmacy School at the Medical College of Virginia. Resigning from the Navy in 1930, Dr. Hughes worked at Carnegie Institute with Dr. Davenport on studies of inventive genius.

In 1934 he moved to Columbia University where he earned his M. A. in zoology and genetics. Here too he met and married Elizabeth Drumtra who received her M.A. from Columbia in zoology. In 1938 Dr. Hughes came to the Medical College of Virginia as an Associate Professor of Biology. After receiving his Ph.D. from Columbia in cytogenetics in 1940, he was appointed as Professor and Chairman of the Department of Biology at MCV until his retirement in 1970.

He was called to active service in January of 1941 and trained in mine warfare. In April of 1941 he was sent as Assistant Naval Attache' to the American Embassy in Britain as a mine warfare observer. After his return in September 1941, he was attached to the Mine Warfare section in Washington as Executive Officer. After the war, he returned to civilian life taking up his post at MCV. He continued in the Naval Reserve thereafter rising to the rank of Captain USNR. From 1950 he was Commanding Officer of Naval Reserve Research Company 5-5, which met at MCV to discuss scientific developments and projects. For encouraging this and similar activities, MCV received the Department of Defense Reserve Award.



His major interests were in cytogenetics and radiation genetics. Publications included among others: "Family Studies of the Facial Complex," 1963 with B. L. Hanna and M.E. Turner, and "A Review of the Family Anoetidae (Acari)," 1956 with C. G. Jackson. He also edited with H. Leidhiser, Jr. , a book of papers, "Exploring Virginia's Human Resources," resulting from a Symposium in 1964 , which he organized under the auspices of the Virginia Academy of Science . He organized VCU seminars on Human Ecology in 1970 , the first of its scope in the Richmond area, and another such seminar the following year. The guest lecturers were a group of outstanding professionals in various fields who attracted a good deal of thoughtful editorial comment in the local newspapers on matters of the environment.

Always active in community service, from 1965-66 Dr. Hughes was President of the Virginia Academy of Science. As a Council member, he offered strong support to the Junior Academy and as President continued his interest in and involvement with the Academy. He was elected to the first class of Fellows of the Virginia Academy of Science and to honorary life membership. In 1970 he received the Virginia Academy of Science Ivey F. Lewis Distinguished Service Award. Dr. Hughes also served as President of the Virginia League for Planned Parenthood from 1966-68.

### **The Dream to Fruition**

The establishment of the Science Museum embodies his belief that ideas are adventure and learning is fun. This was an exciting period in Dr. Hughes life for he enjoyed working with young people. This was truly a significant contribution to the educational experience -- one that takes place outside the formal classroom. There was a distinct need for a facility in which young people could come together to enrich relationships and extend the learning process. Dr. Hughes was the potent force in this scientific educational evolution.

### **The Roscoe D. Hughes Human Genetics Fund**

This fund was established as a memorial to Dr. Hughes in 1981 to support the academic activities of the Department of Human Genetics at the School of Basic Health Sciences MCV/VCU. Specifically it provides for student support in the field of Human Genetics. Each year the Roscoe D. Hughes Fellowship is awarded to an outstanding student. Dr. Hughes felt that youth is that time when a student must capture the impetus of the moment and respond with the vigor that makes possible the realization of his/her full potential. Through the generous support of our alumni and friends we have been able to provide educational opportunities for the scientific student who otherwise might be found wanting. This fund is most worthwhile and will continue to have a dramatic impact on the life and future of the study of human genetics here at this University.

Taken from material supplied by:  
Elizabeth (Drumtra) Hughes ,  
Elizabeth (Hughes) Waugh and  
William D. Hughes



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